Assessment of the Availability of Groundwater for Residential Development in the Rural Parts of Yakima County, Washington

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(Under Contract by Yakima County)
For Technical Analysis and Assessment of Groundwater Mitigation Strategies

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Foreword

The need for identification of mitigation options for rural domestic groundwater is a result of recent changes in Washington State policy and legal requirements for water rights, water use, implementation of the Growth Management Act, and the Comprehensive Planning requirements for Counties. At the time of the writing of this document, Yakima County expects that these and other policies, rules, and laws will continue to evolve over the next several years.

While this document is largely a technical document, the content of the document is a reflection of current and to some degree anticipated changes in laws and policies. Accordingly, as the policy and legal environment changes, it may drive changes to the scope of the technical information in the document, or how that information can or cannot be used to identify groundwater mitigation options for rural domestic uses. As the document gets updated into the future, the changes to the document will be documented in a similar *Foreword*.

Acknowledgments

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Executive Summary

In order to consider the best approach for preserving the option of rural domestic use development within Yakima County, the County contracted with Vaccaro Groundwater Consulting LLC, to identify groundwater use strategies based on hydrogeologic availability that could be used in particularly-defined geographic “domains”. The strategies would take into account specific measures that could be taken within specific domain, or “sector” thereof, that would mitigate the effect of water use on the aquifer system, senior ground and surface water rights, flow-related habitat conditions and habitat use.

The basic background information for groundwater in the Yakima River Basin was derived from a series of publications of the U.S. Geologic Survey (USGS) completed as part of a multi-year study of the groundwater resources of the basin. The report relied upon, and utilized, the suggestion of the Washington Department of Health that average residential use is 350 gallons per day (0.39 acre-foot per

year). The information analyzed for defining the domains, estimating potential future rural domestic development, and generally assessing the potential effects of future groundwater pumpage on streamflow was garnered from the Yakima County Geographic Information system. The primary information used in the analysis were Land Ownership and Land Use Authority, Land Use/Zoning, Major Water District Boundaries, Census Data, Existing Residences and Residential-Land Undeveloped Parcels, Location of Irrigation Districts and Canals/Laterals, Points of Diversion for Surface Water-Allowable Quantity and Priority Date, Fish Coverages, Hydrogeology, Groundwater Levels, Well Records, Pumpage Records, Groundwater Recharge, and Building Permit Trends.

Pumpage for potential future wells was assessed by estimating, to the extent possible, where the effects of Pumpage would propagate, whether in main stem streams (Bumping, Tieton, Naches and Yakima Rivers) or tributary creeks. In the case of tributary basins with naturally flowing creeks, an estimate was made for well depths that may principally extract groundwater from the sub-regional to regional flow system and not the local shallow system.

The report leads to the conclusion that groundwater mitigation strategies and estimated sources of water for rural development that avoid impacts to tributaries would include purchase of main stem rights, purchase of tributary rights where they are available and identified and suggested well depth standards. There is strong emphasis on the development of wells depth standards in the tributary basisn that would mostly avoid impacts to flows in the tributaries, and would impact flows, and senior rights mostly in the main stem reaches.

Thirty sectors, within thirteen domains, were identified and analyzed. Table 1 of the report lists for each sector, the area of private lands, population, population exclusive of water service district, existing residences, existing residence not in municipalities, buildable lots not in municipalities, buildable lots not in municipalities but within irrigation district boundaries, the number of diversions, the quantity of diversions, the potential future demand on buildable lots outside municipalities and the potential future demand on buildable lots outside municipalities bit within irrigation district boundaries.

The report identifies measures to mitigate rural domestic groundwater development on the vast majority of currently undeveloped rural residential parcels in Yakima County. The report identifies a source and estimated amount of water that should be designated for future development in each domain. The report also identifies those domains where there are indications that the deeper basalt aquifers are declining such that well depth limits should be followed so as to avoid impacting those aquifers and the groundwater rights associated with them. Mitigation for the development of those sources would occur from acquisition of water rights in that source [i.e., main stem water rights ("M"), main stem water rights with estimated well depths ("MWD"), tributary water rights ("T"), and main stem water rights with estimated well depths and/or Tributary water rights ("MWD/T")]. See Tables 2, 3, 4, 5 (pages 76-82). Recommended strategies for well depths for new residential wells include recommended depths below the altitude of a main stem stream, other well depths, varying over a given area, predicated on encountering a water producing zone. The report also identifies the need for a more detailed analysis of the Ahtanum/Wide Hollow Domain due to complexity of the hydrogeologic conditions in that watershed and the ongoing water right adjudication in the Ahtanum Watershed.

Introduction

Yakima County is a semi-arid county, east of the Washington Cascade Mountains, receiving approximately 7 to 9 inches of precipitation annually in the lowlands. Yakima County agriculture depends largely on irrigation surface water supplied U.S. Bureau of Reclamation's Yakima Project. The basin was characterized as over-appropriated in 1904 and Yakima Basin surface water rights were subsequently defined in concert with the U. S. Bureau of Reclamation authorization of the Yakima Project in December 1905, which is also the priority date of Reclamation's water rights in the Basin. More recent court cases have established that the Yakama Nation has a water right to maintain fish life as a result of the 1855 treaty with the United States, the priority date of that water right is "time immemorial". It is now generally accepted that Yakima River basin surface water and ground water constitute a hydrologically holistic system. Municipal and rural domestic water supply generally is provided from groundwater sources, and may impact those senior water rights (established before and including 1905). RCW 90.44.050 provides for the supply of rural domestic water through the use of "exempt wells", which can pump up to 5,000 gallons per day for residential use. ,

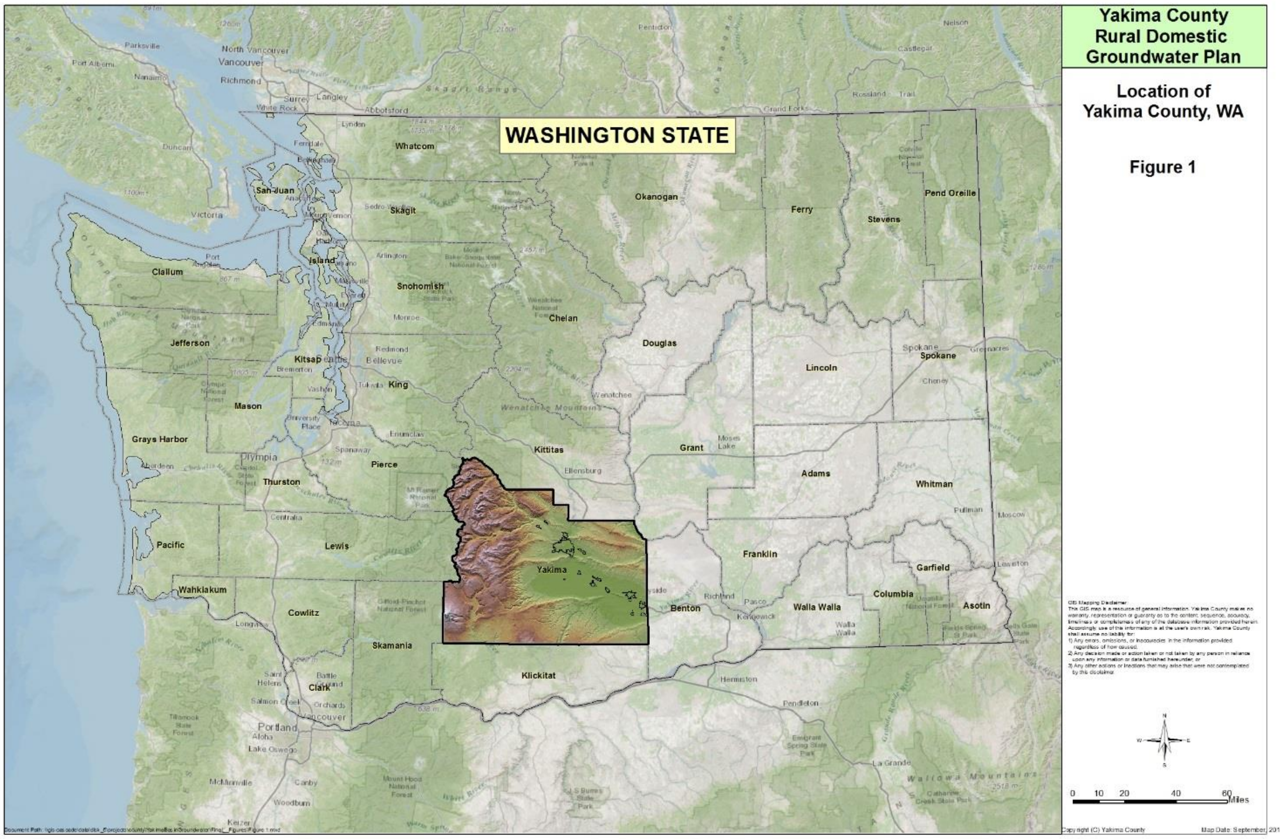
Yakima County (fig. 1) is the eight largest of the 39 counties in Washington State with a population of 247,044 (2013) and an average household size of 2.99 (Washington State Office of Financial Management). About 52 percent of the total population reside in unincorporated areas. The 2010 National Census to 2013 indicated that Yakima County's population grew by 1.65 percent, or 0.55 percent per year. Accordingly, Yakima County population is expected to grow between 0.5 to 1 percent per year. Recent State Court decisions on the requirements of the Washington State Growth Management Act and County Land Use plans result in a positive duty for Yakima County to ensure that water for development is legally and physically available. Closure of the portions of the Yakima Basin to exempt well construction has already occurred in Kittitas County, which in turn has had effects on the development patterns and a large effect on the value and marketability of legal lots which can no longer be developed with the use of exempt wells. Therefore, the County may need to secure future domestic water supply. Current Washington law provides sufficient authorization for counties to address this requirement. The Water Resources Act of 1971 (Ch. 90.54 RCW), provides that "All agencies of state and local government, including counties and municipal and public corporations, shall, whenever possible, carry out powers vested in them in manners which are consistent with the provisions of this chapter." Water for growth outside of municipalities can be met by the drilling groundwater wells meeting the exemption provided by RCW 90.44.050, expansion of existing Department of Health Group A or B Systems, or by development of new municipal water districts of Group A Systems.

On December 10, 2013, in anticipation of the possibility that the Department of Ecology might, by rule, declare the unavailability of water for development in Yakima County, the Yakima County Board of Commissioners adopted Resolution 399-2013, "In the Matter of the Formation of the Yakima County Water Resource System." Yakima County's Water Resource System (YCWRS) will expand its current water systems to address a County-wide rural-domestic water supply to be available to those who would otherwise rely on the "exempt" well strategy offered by RCW 90.44.050. Information regarding the location and extent of groundwater resources in the County will also be used to assist in the preparation of required updates to the County's Comprehensive Plans and implementing regulations.

Groundwater withdrawal may have effects on senior water rights, including the Yakama Nation Water right for the protection of fish life. Thus, the potential effects of future groundwater withdrawals on senior water users and habitat conditions need to be identified by the County so that the potential impacts of these future withdrawals are addressed and mitigation strategies developed for those impacts. A framework for helping to assess such strategies is described in the following sections of this document.

Using hydrologic, hydrogeologic, aquatic and domestic demand databases, this report characterizes the County groundwater resources, future groundwater demands from domestic water supply, aquatic uses and mitigation strategies for domestic water use by location.

Figure 1. Location of Yakima County, Washington



Purpose and Scope of this Report

The purpose of this report is to use available data to delineate distinct surface water and groundwater "domains" in Yakima County that can be used to identify groundwater use strategies based on hydrogeologic availability. Prior to selection of specific mitigation measures within a given domain or a subarea of a domain (herein called a 'sector' or 'sectors'), the general characteristics of the aquifer system, surface water rights (quantities, seniority dates, and in some cases, actual use), flow-related habitat conditions, and habitat use also are characterized. This report defines the domains and their overall characteristics and potential strategies. A draft list of potential strategies identified in this document are briefly summarized in Appendix A.

Characterization of Groundwater Domains

Department of Ecology Scoping Map

The study starting point for consideration of groundwater was an unofficial map prepared by staff of the Washington State Department of Ecology (WDEE) "Scoping Map". While the map was without regulatory effect, it assisted in identification of groundwater use strategies and mitigation of water use effects. It included four categories of areas called "sub-basins", some named and others numbered. The categories are generally categorized by the limitation of junior surface-water users during years when water supply is limited, and a "water call" (request by senior right holders to reduce or eliminate use by junior right holders) had been made in the past. Three of the categories defined potential mitigation concepts for each of the sub basins. Each of these categories were color coded on the map.

This map is based on a simplified assumption that absent any further analysis, each tributary basin is associated with a distinct groundwater supply in which is in continuity with the surface water streams. For areas adjacent to main stem rivers, the assumption was that the groundwater is in continuity with the river. Listed below are the wording for the four categories defined in the scoping map.

1. Green: Mitigation for TWSA impacts would be relatively easy to accomplish with a main stem pre-1905 water right acquisition.

2. Red: Mitigation for impact to senior right within the sub-basin would not effective with a main stem pre-1905 right; an in-basin water right would be necessary for at least a portion of the irrigation season.

3. Yellow: Mitigation may be possible with a main stem pre-1905 right, with the potential need for a supplemental in-basin project to address adverse fisheries impacts.

4. Gold: One or more underlying aquifers with are either susceptible to chronic declines or are experiencing chronic declines. In such a chronically declining aquifer, mitigation for impact to existing groundwater right would not be effective with a main stem pre-1905 right.

The fourth category of 'Aquifer Concern Areas' (ACA) boundaries that were much generalized, and were initially drawn to encompass broad areas where declines are occurring, including areas outside of declining levels (J. Kirk, oral commun., DOE, 2015) . The ACAs represent areas to be analyzed by DOE in the future. All of the ACAs were delineated areas below Selah Gap.

This conceptual scoping map provided the initial framework for this County-wide assessment and was analyzed for all of the work components. This assessment was initiated to provide analysis of the actual conditions within areas of Yakima County as opposed to the assumptions in the "Scoping Map". The policy implications of the scoping map, especially the potential for lack of markets in the “red” areas and the need for unknown mitigation in the “yellow” areas, put a strong emphasis on exploring whether groundwater mitigation strategies (specifically well depth or well location) could be developed that minimized effects on stream flows. For example, mitigation measures that avoid impacts to flows in tributaries would therefore provide a much more comprehensive (in terms of areal extent and potential service areas of the proposed Yakima County Water Resource System) and implementable solution to the need for effective mitigation of the effects of groundwater withdrawal on senior water rights

Hydrogeologic Conditions for Definition of Groundwater Domains

The domains generally contain similar hydrogeologic conditions and/or well-defined groundwater boundaries such as anticlines (geologic structures that greatly impede groundwater flow across them), and, in some cases, limitations to junior water-right surface-water users in dry years. In addition, most domains are hydrologically distinct, including the identification of distinct drainage areas (watersheds) for selected tributary basins. Defining domains in this way allows the development of mitigation strategies which are appropriate to the hydrogeologic conditions. For example, a main stem river domain would be terminated where another main stem river discharges to it. Hydrologically distinct areas can provide valuable information for long-term planning. The above three factors (hydrogeologic similarity or well-defined groundwater boundaries, water use limitations, and hydrological distinction) when combined, were used to define some tributary basins as distinct domains, especially when considering confounding factors such as the presence of selected fish species.

The boundaries of the identified domains were defined such they not only included the lands that may have future development but also identified the particular area clearly. For example, a domain boundary may include a complete watershed to highlight that the lands of interest are contained in this distinct watershed or, for a narrow river domain, the boundaries clearly show that the domain follows the river. These selected boundaries also facilitated the calculation of important identifying numbers within each domain. Thus, for some areas within a domain, there will not be any future development potential because it may lie, say, within U.S. Forest Service National Forest boundaries.

For each domain, an estimated source of mitigation water for future rural development is identified. Mitigation strategies for individual domains are primarily directed towards mitigation of the effects upon senior water-right holders in the basin. Mitigation strategies may include purchase of main stem rights, improving irrigation efficiencies (which may not produce very much consumptive use for large-scale mitigation but can meet mitigation demands for local small-demand domestic well use), purchase of rights or a variety of contractual agreements within individual tributary drainages (watersheds), placement of water rights into the trust water right program, and artificial recharge of groundwater or storage of surface water. The effects of future water development in part of a domain may be met by mitigation of the main stem water supply, and in another part the effects of such development may necessarily only be by mitigation of a tributary water supply.

Information Analyzed for Characterization of Domains

The following sections describe the information analyzed for defining the domains and the estimated source of mitigation water for future development. The information also provides for some of the framework for developing a County-wide Land-Use Plans and addressing potential GMA issues.

Background Information

The basic background information for groundwater in the Yakima River basin was derived from a series of publications of the U.S. Geological Survey (USGS). These publications were completed as part of a multi-year study of the groundwater resources in the basin. All publications are available at *http://wa.water.usgs.gov/projects/yakimagw*. The publications from which information were analyzed for this part of the Plan are:

- Jones, M.A., Vaccaro, J.J., and Watkins, A.M., 2006, Hydrogeologic framework of sedimentary deposits in six structural basins: USGS Scientific Investigations Report 2006-5116, 24 p., 7 pls.
- Jones, M.A. and Vaccaro, J.J., 2008, Extent and depth to top of basalt and interbed hydrogeologic units, Yakima River Basin aquifer system, Washington: USGS Scientific Investigations Report 2008-5045, 22 p., 5 pls.
- Vaccaro, J.J., and Sumioka, S.S., 2006, Estimates of groundwater pumpage from the Yakima River Basin aquifer system, Washington, 1960-2000: USGS Scientific Investigations Report 2006-5205, 56 p.
- Vaccaro, J.J. and Olsen, T.D., 2007, Estimates of ground-water recharge to the Yakima River Basin Aquifer System, Washington, for predevelopment and current land-use conditions: USGS Scientific Investigations Report 2007-5007, 30 p.
- Vaccaro, J.J., Jones, M.A., Ely, D.M., Keys, M.E., Olsen, T.D., Welch, W.B., and Cox, S.E., 2009, Hydrogeologic framework of the Yakima River Basin aquifer system, Washington: USGS Scientific Investigations Report 2009-5152, 106 p.
- Ely, D.M., Bachman, M.P., and Vaccaro, J.J., 2011, Numerical simulation of groundwater flow for the Yakima River basin aquifer system, Washington: USGS Scientific Investigations Report 2011-5155, 90 p.
- Magirl, C.S., Julich, R.J., Welch, W.B., Curran, C.R., Mastin, M.C., and Vaccaro, J.J., 2009, Summary of Seepage Investigations in the Yakima River Basin, Washington*:* U.S. Geological Survey Data Series 473

- Keys, M.E., Vaccaro, J.J., Jones, M.A., and Julich, R.J., 2008, Hydrographs showing ground-water level trends for selected wells in the Yakima River basin aquifer system, Washington: U.S. Geological Survey Data Series 343, 1 p.

In addition, the following report provided information on generalized estimates of natural streamflow for some of the smaller ungaged streams within Yakima County.

Mastin, M.C. and Vaccaro, J.J., Watershed models for decision support in the Yakima River Basin, Washington: USGS Open-File Report 02-404, 46 p.

Map and Data Information

This section describes the information analyzed for defining the domains (including estimated sources of mitigation water) and in some cases, the partitioning of a domain into sectors. Not all of the information was utilized for each domain. The development of this database provides a framework for development of future plans. Excluding well-log images, the entire database is in the Yakima County Geographic Information System (GIS) (M. Martian, personal communication, 2015). For analyzing the map data, most of it was portrayed by draping it over the existing GIS digital elevation data for the county.

The main inputs for analysis are provided by the following sections:

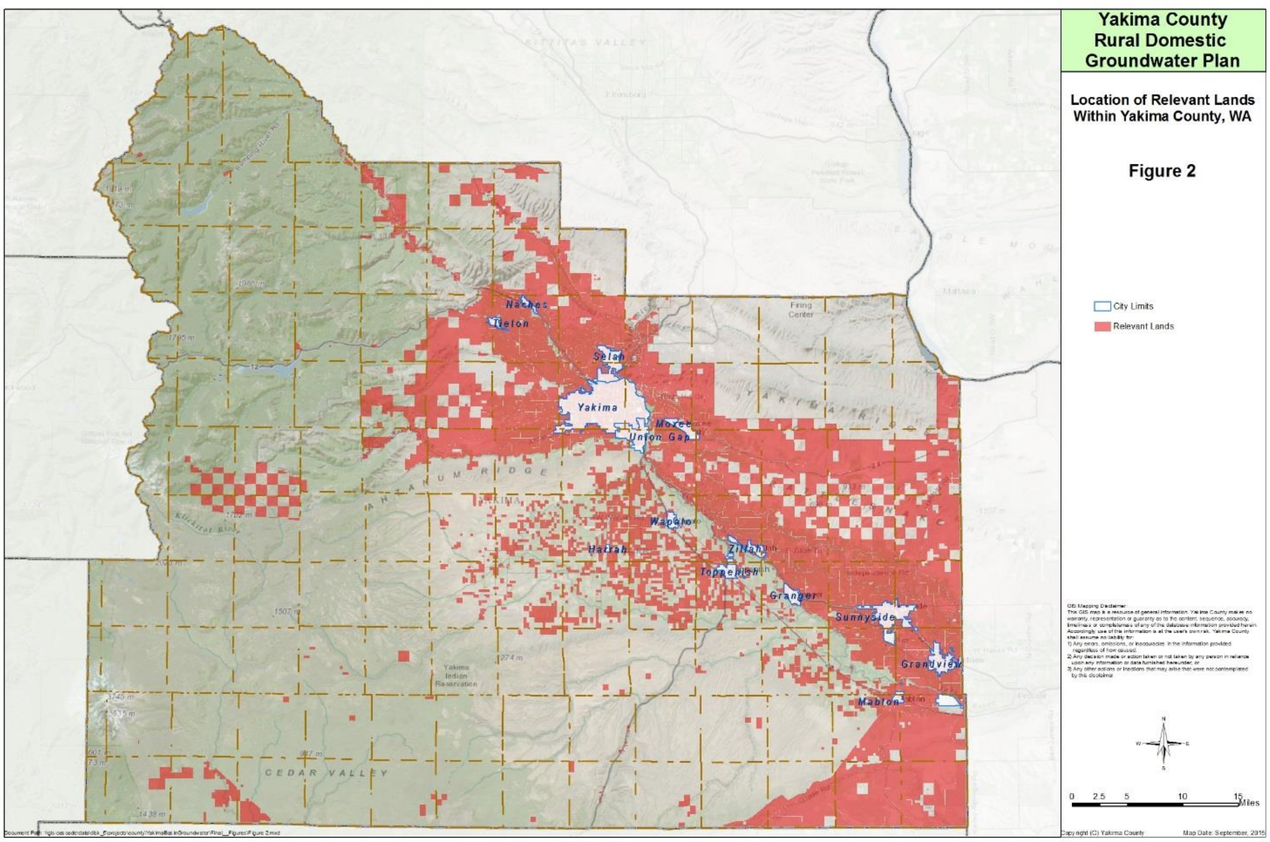
- Land Ownership and Land Use Authority
- Land Use/Zoning
- Major water District Boundaries
- Census data
- Existing Residences and Residential-Land Undeveloped parcels
- Location of Irrigation Districts and Canals/Laterals

- Points of Diversion for Surface Water--Allowable Quantity and Priority date
- Fish Coverages
- Hydrogeology
- Groundwater levels
- Well Records
- Pumpage Records
- Groundwater Recharge
- Building Permit Trends

Land ownership and Land Use authority

Yakima County's land area is 4,296 square miles, but the land area developable pursuant to subdivision or building permits approved by Yakima County is only 955 square miles. That is, various parts of the County's land area were excluded from this assessment using the land ownership information available from the Yakima County Assessor and the County's GIS analysis of that information. U.S. Forest Service, U.S. Army, Washington State Department of Fish and Wildlife (WDFW), and Washington State Department of Natural Resources (DNR) lands were excluded. Lands within municipalities (based on city boundaries) also were excluded because each municipality has control of planning for water supply within its boundaries. The lands within the Confederated Bands and Tribes of the Yakama Nation reservation boundary within the County were excluded; this area includes lands developable pursuant to County subdivision or building permits but the water permits are administered by the Yakama Nation. Two areas which lie within Yakima County were also excluded from this assessment. The first was the area east of the Moxee Valley (the Blackrock-Cold/Dry Creek Valley) that drains eastward toward the Hanford Nuclear Reservation and the Yakima River. This area has no perennial streams and groundwater levels for the hydrogeologic units (Vaccaro and others, 2009) show that groundwater is moving towards the Columbia River-any pumpage effects would be propagated to the Columbia River. The second was the part of Horse Heaven Hills within the County that is a drainage area for the Columbia River. The total land area that was assessed is 675 square miles, representing about 16 percent of the total lands within Yakima County. The resulting map shows the consequent remaining lands that may require groundwater for future development pursuant to subdivision or building permit approval by Yakima County (fig 2.). The domain assessments presented below are relevant to these remaining lands, which are referred to herein as "relevant lands." Two large water districts (Terrace Heights and Nob Hill) covering 23 square miles are included in two of the domains but are considered separate entities, much like municipalities, for parts of this analysis.

Figure 2. Location of relevant lands within Yakima County.



Land use/Zoning

Current land use and Yakima County zoning maps provided information on the location of existing residential and agricultural lands. Rural residential uses are permitted in agriculturally-zoned lands. When laid over other GIS information, land use and zoning maps provide a larger picture of locations where non-municipal, projected growth can occur and the density/type of that growth. When laid over maps containing other information, it may also suggest where changes in zoning might be warranted. As part of the current land use, aerial photography from 2013 also was incorporated for several of the domains. The photography information within a domain was used to help verify irrigated areas near irrigation district boundaries, and in some areas it showed that there were no existing county roads to a potentially developable parcel.

Major water district boundaries

Water-district boundaries identified areas where future growth would be supplied by water from those districts. These areas generally were excluded from the domains-including their potential future demand. The two districts accounted for are the Nob Hill (private) and Terrace Heights (Yakima County) Water Districts. The future pumpage from within these two districts are not considered part of the exempt pumpage that would otherwise be served by groundwater wells exempt from permitting pursuant to RCW 9044.050.

Census Data

Census data from the 2010 National Census provided information on the number of people in each domain, the number within municipal boundaries, and the number outside municipalities and the two water districts that are served by exempt wells or Group A or B water systems. These numbers provide the basic information on existing service needs and water demand for developing future plans.

Note that Group A systems outside of the two major water districts were not explicitly accounted for in this analysis. Census information from the Washington State Office of Financial Management (2013) update to the 2010 census was incorporated when applicable.

Existing Residences and Residential-Land Undeveloped Parcels

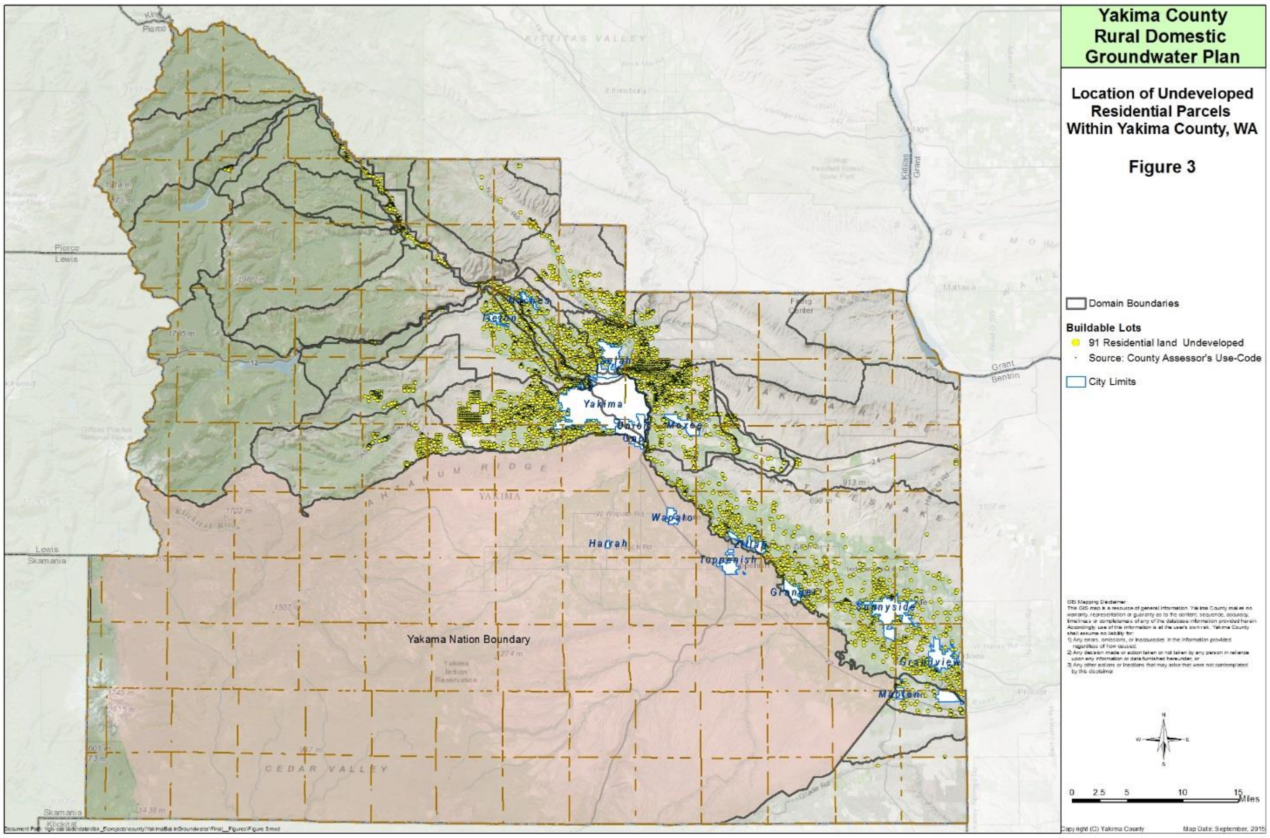
The Yakima County Assessor's records show parcels with existing residences. The aggregate of these parcels was used to further indicate the current water demand within domains. For example, there are currently 61,901 parcels with existing residences in the County, with 5,162 of these within the boundaries of the Confederated Bands and Tribes of the Yakama Nation lands. Of the total existing parcels, about 17,650 residences occur outside of municipalities and the two water districts, and about 74 percent of these parcels are in irrigation districts.

For this analysis, Residential land, Undeveloped (herein called 'RLU'-County Assessor nomenclature) parcels were used as a basis to project the area extent of future rural development and to some extent, future water demand. The aggregate of these parcels can be considered an estimate of the long-term cumulative impact of future development in unincorporated areas. The RLU parcels in a domain (based on the County Assessor information for code 91 as of July 2015) indicate the estimated amount of water supply needed to satisfy future development on existing parcels relying on exempt wells. The estimate may be regarded as marginally conservative, however, because undeveloped parcels in some locations likely will not be developed as they are not conducive to building due to the landscape and/or lack of services such as roads, power, emergency access, and communication ability. The concentration of RLU parcels in some domains (fig. 3) show that some areas will experience a larger future demand more than others. The degree to which a mitigation strategy or strategies could allow the development of existing parcels is a critical criteria in evaluating mitigation effectiveness.

The total number of County RLU parcels as of July 2015 within the Yakima River basin is 6,124 and about 879 are in the two major water districts. About 2,363 parcels have the potential to be built out over ten years based on the Washington State Office of Financial Management 2013 population estimate, average household size, and a growth rate of 0.55 percent with 52 percent living in unincorporated areas. Suggesting that over 20 years more than RLU 4,700 parcels may be built out.

Note that existing residences and RLU parcels continually change over time-essentially a moving target. Therefore, the numbers in this report may differ from the actual numbers after completion of the report, even after one or two days upon completion. Effort has been expended to keep these numbers up to date as the report has progressed. Excluding Table 1, final numbers in the report are based on an analysis completed in July 2015. Any differences in the future will be very small compared to the total number of residences and RLU parcels reported herein.

Figure 3. Location of residential land, undeveloped parcels within domains.



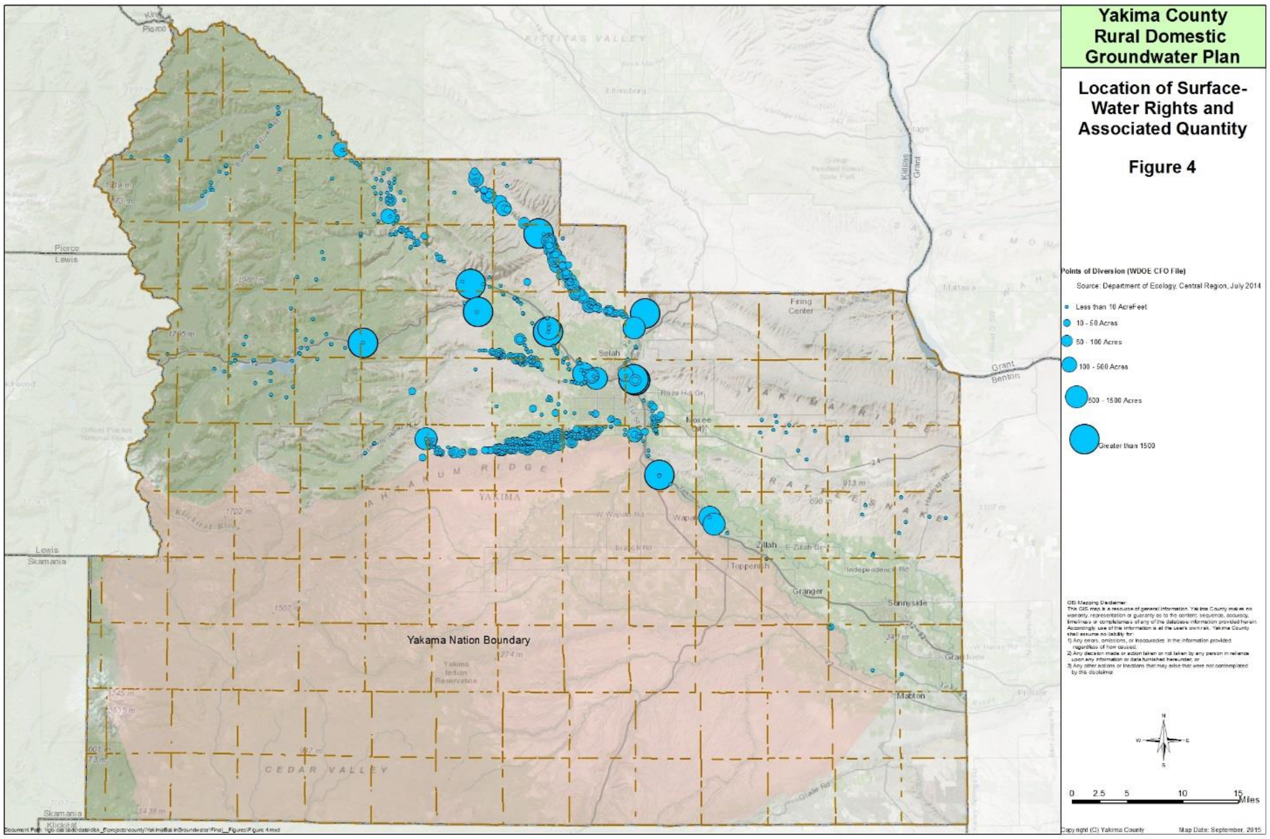
Location of Irrigation Districts and Canals/Laterals

The location of irrigation districts and their delivery system provided information for future water demand and potential mitigation strategies. Most parcels in irrigation districts will be provided water for lawn irrigation by a district and this can result in a reduction of water demand by about 57 percent (Vaccaro and Sumioka, 2006). As of July 2015, about 67 percent of the RLUs are in irrigation districts. Therefore, in estimating water demand for growth, a lower value of a residential-exempt water use can be used. The location of a district and its proximity to areas that may be good for groundwater recharge facilities also provides information for analyzing potential mitigation strategies. Recharge in various domains has increased by one to two orders of magnitude (Vaccaro and Olsen, 2007) because of the delivery and use of surface water in irrigation districts. The increased recharge allows for new residential pumpage in parts of the domains without concomitant groundwater level declines. Thus, mitigation strategies can be oriented to the purchase of water for consumptive use and not for addressing declining groundwater levels. In following sections this information is referenced as ‘irrigation districts’.

Points of Diversion for Surface Water--Allowable Quantity and Priority Date

The location of the Points of Diversion (POD) for surface-water rights (WDOE, digital file, written communication, N. Riddle, 2014) gives the broader picture of where diversions occur, their allowable quantity, their priority date, and where they may be impacted by pumpage. Within the relevant lands of Yakima County there are 876 PODs with an allowable quantity of 1,230,242 acre-feet (table 1). The map of rights (fig. 4), almost all of which have been adjudicated (in Yakima County Superior Court, *In re Aquavella*), also provides the County a framework for where water-right purchases may have the largest benefit. The allowable quantity is based on the adjudicated values and may change based on actual use of water after the adjudicated date. In following sections this information is referenced as ‘diversions’; note that some of these PODs are springs and not direct diversions from a stream.

Figure 4. Location of surface-water rights and associated quantity. From Washington State Department of Ecology, Central Region, July, 2014.



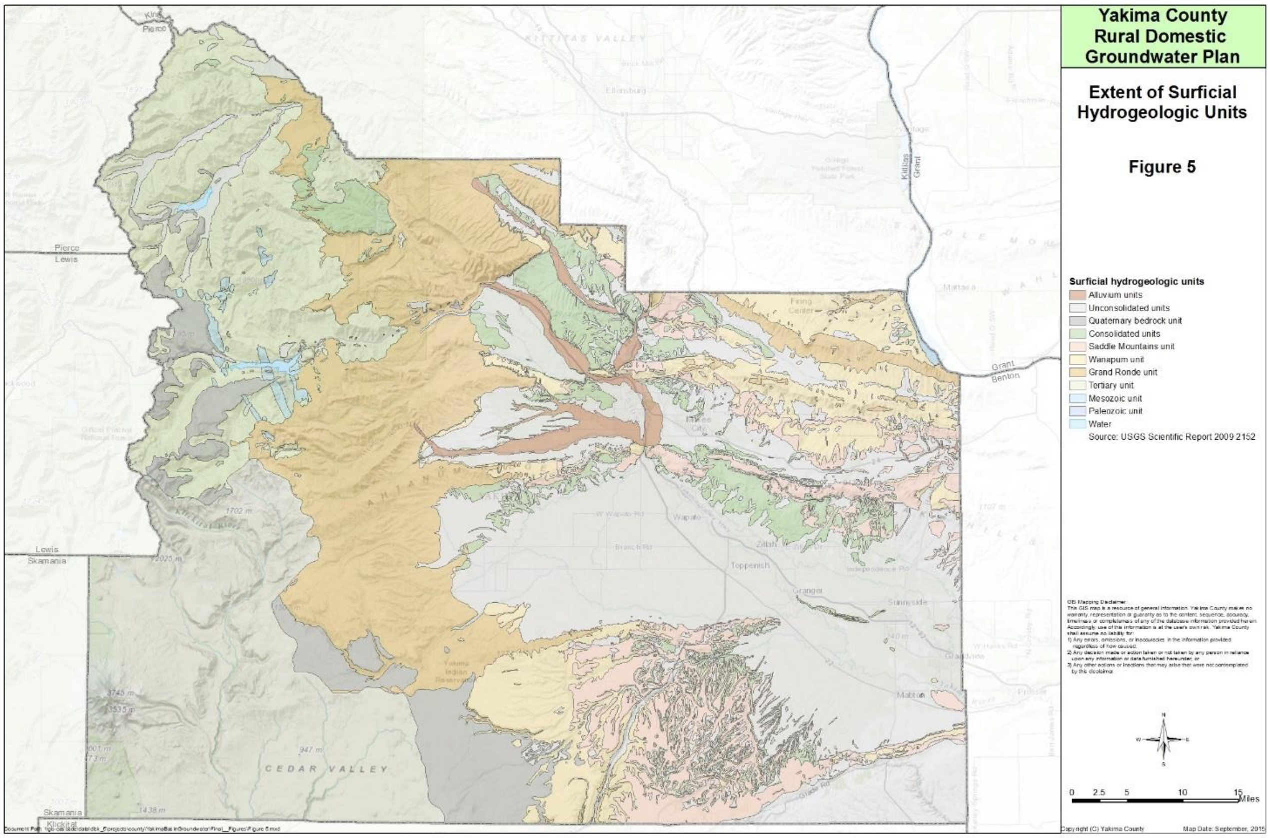
Fish Coverages

GIS layers representing the presence of fish were obtained from WDFW and the Yakama Nation. For example, the WDFW SalmonScape interface can be found at http://apps.wdfw.wa.gov/salmonscape/map.html). Depending on the GIS fish coverage used, fish types ranged from resident to fluvial to anadromous. This GIS information was primarily used to estimate the potential impact of future pumpage in domains with smaller tributary creeks. For example, several small steep tributaries are not identified as having fish presence. Thus, new residential wells would not have an impact on fish habitat (and any associated senior rights with habitat) and effects of new wells on downstream senior water rights could be mitigated with use of acquired main stem water. In the following sections this information is referenced as ‘fish presence’.

Hydrogeology

The types of geologic materials from which wells withdraw water from are important for future planning. GIS layers for the hydrogeologic information developed during the USGS Yakima River basin study were obtained by the County’s GIS Department. This information was from Jones and others (2006), Jones and Vaccaro (2008), and Vaccaro and others (2009). Figure 5 shows the generalized extent of the surficial hydrogeologic units within the county. The Yakima River basin is located in what is termed the Yakima Fold Belt, which is characterized by a series of anticlinal ridges and synclinal basins that essentially partition the groundwater flow system (Vaccaro and others, 2009). The anticlines function as groundwater flow barriers. The information included in this analysis was for the surficial extent of units, the framework for the basin-fill sedimentary deposits (location and extent of defined units), and the extent and depth to/altitude of the top of the three basalt hydrogeologic units: Saddle Mountains, Wanapum, and Grande Ronde units, and the two interbeds: Vantage and Mabton Interbeds. When appropriate, the mapped folds and faults from Jones and others (2006) and Jones and Vaccaro (2008) were included in the analysis, as were the published hydrogeologic sections. Basin-fill deposits and sediments are used interchangeably in the following sections. Herein, ‘extent’ generally is used as a term to represent: lateral extent, thickness, depth to a top of a unit, and altitude of the top of a hydrogeologic unit.

Figure 5. Extent of surficial hydrogeologic units. From Vaccaro and others, 2009.



Groundwater Levels

Groundwater levels from Vaccaro and others (2009) were used in the analysis for several of the domains. Water levels were for the basin-fill deposits, and the three basalt units. The levels provide information on the direction (lateral and vertical) of groundwater flow, which was important for some of the domains. For example, if flow is towards the Yakima River and not a tributary stream, then mitigation for pumpage could likely be accomplished through acquisition of senior rights to main stem Yakima River water-either through water right purchases or, to lesser extent local efficiency gains in irrigation districts. For some domains, long-term groundwater level hydrographs (Keys and others, 2008) also were analyzed. In following sections this information is referenced as stated in text.

Well Records

Well information was analyzed for selected domains. The well information included: location, depth, water level, and type of materials penetrated and finished in. Well information was obtained from Washington State Department of Ecology's website *https://fortress.wa.gov/ecy/waterresources/map/WCLSWebMap/WellConstructionMapSearch.aspx* and from the USGS National Water Inventory System (http://waterdata.usgs.gov/wa.nwis.gw).

Analysis of the well information served several purposes. For example, if analysis of well logs showed that most of the wells in a part of a domain were deep (no water found in the upper parts of the system), with water levels much below a creek level, the effect of pumpage on the creek may be presumed to be minimal. The logs may show that the upper part of the system consists of poorly permeable Ellensburg Formation material and may be unsaturated or seasonally saturated. Well logs show that in parts of some the tributary basin, coarser-grained basin-fill sediments tend to occur along the drainage network, and that they overlie semi-confining to confining units. Water entering these sediments would follow short local flow paths to the stream and recharge to the deeper part of the aquifer system would likely be minimal. Outcrops of productive zones in the system provide a conduit for recharge reaching these deeper parts. For example, the Grande Ronde unit may be the surficial unit in an upper part of a basin and is overlain by one or more units in the lower part of a tributary basin. Most of its recharge that supplies water to wells would occur where it outcrops in the upper part. The well-log information is referenced as "well logs" in the following sections.

Pumpage Records

A variety of pumpage information was incorporated into this analysis, either directly as part of the analysis or for use in future planning activities. Within the Yakima River basin, about 9 percent of the pumpage is for domestic or non-municipal public water supply (Vaccaro and Sumioka (2006). For

Yakima County, Vaccaro and Sumioka (2006) estimated exempt pumpage to be about 15,000 acre-feet at a maximum. About 84 percent of pumpage from permit-exempt domestic use wells was from the basin-fill sediments. Generally, basin-fill aquifers have shallow water tables, which enhance return flow from septic systems but pumpage from them can affect streamflow.

Ely and others (2011) estimated that about 26 percent of the exempt well pumpage resulted in a reduction in streamflow. Their estimate was based on monthly exempt pumpage and corresponding septic-return flow. That reduction suggests that about 74 percent is returned to the groundwater system through septic system return flow. The Department of Health suggests average residential use (average for the year-less in winter and more in summer) to be 350 gallons per day (0.39 acre-foot per year [herein called acre-feet] or 0.00054 cubic feet per second). Thus, the about 0.10 acre-feet (0.00014 cubic feet per second) is consumptive use. The Department of Health value of 350 gallons per day indicates that the consumptive use for 1,000 residences would be on the order of 0.14 cubic feet per second (100 acre-feet); these values would change throughout a year with smaller values from November through February and larger values from March through October. For the 6,124 RLU parcels potentially subject to County approval of subdivisions or building (including those in water districts), the consumptive use would be about 0.86 cubic feet per second or 621 acre-feet (1,833 acre-feet total potential demand over some 20 years--about one-tenth of one percent of the total basin’s reservoir capacity). The total future demand/consumptive use from new rural domestic wells likely would be less because these RLU parcels include those in the Terrace Heights and Nob Hill Water Districts (water supply from the District’s wells) and 67 percent of the RLUs are in irrigation districts. Potential reduction in irrigation districts over 20 years is about 700 acre-feet of the 1,833 acre-feet total, or about a 182 acre-feet reduction in consumptive use.

The 0.00054 cubic feet per second (0.39 acre-feet) value was used for projecting future demand for the RLU parcels, including those in irrigation districts. As part of the Yakima County Water Resource System, this volume of County-acquired senior water rights would be made available (and perhaps metered in the future) to proponents of subdivision or building permits in rural areas who did not have alternative sources of water rights and proposed to drill new permit-exempt wells. The units of cubic feet per second are best highlighted because that is the measurement of streamflow. For example, if the mean annual streamflow in a river is 350 cubic feet per second, then the annual consumptive use impact from a 1,000 new residences would be well less than a thousandth of one percent (0.14 consumptive use divided of 350), and if summer flows were 10 cubic feet per second the impact also would be small. Similarly, the consumptive use for 100 residences is about one percent of a 1 cubic feet per second. The statewide average daily per capita use is about 80 gallons per day. Thus, with an average household size of 2.99 in Yakima County that translates to 239 gallons per day per household. However, water use in western Washington (incorporated in this number) is much lower than eastern Washington because of the wetter climate, more multi-family dwellings, and reduced risk of wild fires.

As noted previously, the demand value of 350 gallons per day likely could be reduced by about 57 percent for new residences in irrigation districts (about 67 percent of the RLU parcels are in the districts). In other words, the total demand may be reduced by more than one-half. However, this analysis uses 350 gallons per day (0.00054 cubic feet per second or 0.39 acre-feet) in estimating potential future demand for all RLU parcels and the resulting consumptive use (0.00014 cubic feet per second or 0.1 acre-feet) for the those parcels in a domain.

Groundwater Recharge

Estimates of groundwater recharge (Vaccaro and Olsen, 2007) were analyzed for selected areas, particularly for tributary sub basins and or irrigation districts, in order to determine what reaches of tributary streams (creeks) may be affected by surface-water irrigation. It is known that the delivery and application of surface water changes the streamflow hydrograph during the summer months due to increased discharge from surface-return flows and irrigation-enhanced groundwater recharge due to shallow groundwater levels. In irrigated areas, water is added to storage to the groundwater system beginning with the priming and running of canals and laterals, and later by the onset of irrigation of croplands. This artificially stored wedge of water discharges to drains, creeks, and the main stem streams throughout the irrigation season and beyond. The resulting change in the natural streamflow hydrograph during the normally low-flow part of the irrigation season can have a negative impact on the aquatic ecosystem. For example, a salmonid redd can become dewatered as the irrigation flows supporting streamflow diminish over winter. Thus, small potential streamflow reductions from new domestic rural pumpage can reduce streamflow (albeit by small quantities) for downstream users but may be beneficial for the aquatic ecosystem—including fish habitat. It should also be noted that naturally there would be not be enough water for downstream users in parts of some tributary creeks but small diversion dams, groundwater discharge, and return flows supply additional water.

Building Permit Trends

Building permit trends were analyzed by the county to estimate where growth was most likely to occur. These projected areas of faster growth with their numerous RLUs may be prioritized by the County for developing mitigation strategies.

Definition of Groundwater Domains

The domains for assessing potential mitigation strategies are described below. The basis for this analysis was to make a general assessment of the potential effects of future groundwater pumpage on streamflow. Pumpage from future wells was assessed by estimating, to the extent possible, where the effects of pumpage would propagate to, such as main stem streams (Bumping, Tieton, Naches and Yakima Rivers) or tributary creeks. For the case of tributary basins with naturally flowing creeks, an estimate was made for well depths that may principally extract groundwater from the sub-regional to regional flow system and not the local shallow system. That is, can pumpage effects mainly be directed to main stem streams where water for mitigation (largely due to storage dams and a larger water market) is much more available? For example, pumping groundwater from deeper in the flow system below a really extensive semi-confining to confining unit would spread out the effects of pumpage on the upper, shallow system over distance and time. The full effects of new pumpage from deeper in the system would therefore not have a one-to-one direct spatial-temporal effect on capturing potential discharge to drains, creeks, and main stem bodies. These estimates represent a conceptual model and are dependent on aquifer system hydraulic characteristics.

Compilation of data in the basin and the development of the USGS numerical model of groundwater flow (Ely and others, 2011) indicate that the interbeds and basalt-flow interiors are at least several orders of magnitude lower in horizontal hydraulic conductivity than parts of the basin-fill deposits and basalt-interflow zones; it also is recognized that in some areas, such as in part of the Moxee valley and in the City of Moxee area, some interbeds provide a source of water. Vertical hydraulic conductivity of the tighter units is even much lower, by as much as two to three orders of magnitude. It is recognized that unmapped ‘holes’ (and in some cases unmapped faults) in these semi-confining to confining units/sections or locally larger conductivities would allow for quicker propagation/response in the upper part of the system. However, acknowledging the lower vertical conductivity, the propagation of effects may be minimal. Future pumpage will result in hydraulic head changes that may be represented by changes in the quantity of vertical flow and or decreased hydraulic gradient (loss in downstream discharge). It should be noted that for most domains, the amount of potential future pumpage is minimal and thus, these effects would not be large and likely would be counter-acted by the additional recharge from septic return flow. For example, if 20 percent of the pumpage in some area of a domain captures tributary basin streamflow, this is counteracted by the 74 percent of the pumpage going to the shallow groundwater system from the return flow. In other words, the leeway for potential capture is 74 percent of the pumpage.

As described previously, some of the domains (typically tributary basin domains) were subdivided into sectors. The basis for the subdivisions was to estimate where potential future pumpage effects would be likely propagated to the either the main stem streams or to a tributary creek. The concept of identifying potential well depths to enhance the likelihood of main stem effects and avoid impacts to tributary flows was integral to the subdivisions. Generally, well depths were estimated based on the depth to a lateral coherent semi-confining to confining unit such as the Mabton Interbed or penetrating a deeper basalt unit where groundwater levels were much lower than shallow levels (and in some cases upper zones identified as being dry in well logs) and indicated a deeper flow system. In other cases, depths were estimated based on the concept of pumpage occurring at some depth below the altitude of a main stem stream where sub-regional to regional flow has an upward, groundwater discharge component to the stream. Depths were conservatively estimated, and it is recognized that pumpage effects from the suggested depths of potential future wells may be nearly the same with either a shallower or deeper well depth. It is recommended that future well depths penetrate, where possible, through either shallow surficial sedimentary deposits into the basalts (in some cases on the Naches River arm into bedrock units) or through the mapped basin-fill units for minimizing tributary creek impacts. However, the drilling of shallower wells that do not withdraw from the very upper part of the basin-fill deposits in tributary basins remains an option because of the potential for purchasing water in tributary basins that have numerous, smaller diversions. In other words, the availability (location and cost) of senior water-rights for purchase will ultimately define the mitigation strategy for some domains or sectors in a domain.

In domains/sectors where there are recommended future well depths for new residential wells, these depths are based on a variety of information. In particular for any area, they are based on mapped surfaces of the hydrogeologic units from the USGS study. These mapped surfaces will inherently have some error in them in between the well data that was used to create the maps. For example, there may be a very old erosional feature between the wells used to map the surface, and thus, the depth to the top of some particular unit may be under estimated in that location. In contrast, there may be a local high in the top of the unit that is unknown and the depth to the top would be less. The potential error in mapped units is unknown, especially because the maps were developed over a more than 6,000 square mile area; some of the area had a reasonable amount of wells information for analysis and other areas did not. Typically, the deeper parts of the system had less well information available for mapping the hydrogeologic-unit surfaces. Thus, it is unknown whether the accuracy (outside of the individual well point used in the mapping) is 50 feet, 100 feet or greater. This accuracy varies by hydrogeologic unit, depth of burial, and availability of well information. For example, the shallower the unit, such as the alluvial unit, the better defined it is.

As described for some of the domains in the following sections, there are two general types of well depths recommended. The first is that a future well is finished below the altitude of a main stem stream such as the Naches River. In this case, the well depth is well defined. The second type recommends well depths that may vary over an area. For example, if a recommended well depth is 400 feet, it may be that a future well may encounter the estimated hydrogeologic unit for withdrawal at 350 feet. This depth would be predicated on encountering a water producing zone, which may first exist at 450 feet. This represents the realities of a complex groundwater system. Except for the shallow basin-fill sedimentary system such as the alluvial unit, there is tremendous variability throughout the county. For example, analysis of well logs show that an existing exempt well may encounter a good water producing zone at 150 feet while the neighboring property did not encounter one until the well was 350 feet deep.

The sub basins defined by WDOE were initially analyzed in the framework of the locations were Yakima County has relevant lands moving in a downstream direction from Bumping River to the mouth of the Naches River. Lands were then analyzed for the area upstream of the mouth of the Naches River and in the Selah structural basin defined by Jones and others (2006). The analysis then worked in a downstream direction with the domains containing WDOE's generalized ACAs analyzed last. Various information was analyzed to develop the domains and, in particular, historical limitations during dry years for surface-water users and fish presence were accounted for. The information examined is documented for each domain. Background information for the relation between water-demand items and each domain is presented in Table 1. Note, that as described previously, if suggested future well depths, which are oriented to main stem stream impacts, are estimated/presented/described for a domain it may be that availability of water for purchase in a domain may result in estimated depths that would be shallower.

The conceptual model for estimating the effects of future pumpage (main stem-tributary), the definition of the domains, and the identification of sectors within domains were reviewed by hydrogeologists from WDOE and YN. Informational and technical meetings were conducted during this process to identify any aspects that may have needed more analysis or clarity in the technical discussion. One outcome was the 'summary' domain map presented later in this report that was recommended by WDOE.

Last, there are several small private parcels in the American River drainage and in the drainage just above Rimrock Lake. These parcels are built out and do not contain any RLU parcels and they are not included in this analysis. In addition, there are eight large parcels in the headwaters of the Tieton River drainage above Rimrock Lake. These parcels are mining claims on USFS lands and generally are already associated with a water right. These parcels also are not included in this analysis.

Table 1 below lists the domains that were identified during the analysis with summary input characteristics used in the analysis and expanded in the section for each domain. These characteristics serve as a starting point for evaluation of appropriate zoning and density.

Table 1. Water and Land Use Characteristics of Groundwater domains, Yakima County, Washington

Table 1: Relation between water demand items and Domains, Yakima County, Washington

Domain	Area of private lands (square miles)	Population	Population (not in Municipalities, Nob Hill, Terrace Heights districts)	Existing residences[1]	Existing residences[1] (not in Municipalities)	Buildable Lots[2] (not in Municipalities)	Buildable Lots[2] (not in Municipalities & in irrigation districts)	Number Diversions	Diversion Quantity	Potential future demand (buildable lots times 0.39 acre-feet) (outside of municipalities)	Potential future demand (buildable lots times 0.39 acre-feet) (outside of municipalities and in irrigation Districts)
		Census Blocks						Active: YRB CFO_Quantities (Ecology)	Certificate_Irrigated_Acres_QT		
Upper Naches	11.42	519	519	757	757	299	0	95	54,653.05	116.61	-
Nile Creek											
Sector 1	0.30	10	10	10	10	0	0	3	16.00	-	0
Sector 2	0.78	141	141	3	3	0	0	5	323.66	-	0
Nile/Dry	0.02	2	2	3	3	2	0	1	-	0.78	0
Dry Creek											
Sector 1	0.09	0	0	4	4	1	0	0	-	0.39	0
Sector 2	0.05	0	0	1	1	0	0	0		-	0
Sector 3	0.03	0	0	0	0	0	0	3	56.63	-	0
Rattlesnake Creek											
Sector 1	0.15	0	0	3	3	9	0	7	201.00	3.51	0
Sector 2	0.22	0	0	1	1	0	0	1	2.20	-	0
Sector 3	0.24	58	58	4	4	0	0	17	374.25	-	0
Lower Rattlesnake	0.17	0	0	11	11	1	0	0	-	0.39	0
Tieton River											
Tieton	1.97	29	29	51	51	13	0	17	106,370.70	5.07	0
Lower Naches											
Sector 1	7.93	718	718	236	236	108	108	23	860.20	42.12	42.12
Sector 2	24.25	7,422	5,754	2,213	1,846	378	367	89	116,848.34	147.42	143.13
Upper Yakima River											
Upper Yakima	32.60	15,027	7,694	4,549	2,377	726	431	20	433,804.20	283.14	168.09
Wenas Creek											
Sector 1	13.83	122	122	40	40	31	0	19	2,015.55	12.09	0
Sector 2	27.90	3,272	3,272	1,050	1,050	236	60	102	14,736.31	92.04	23.4
Sector 2D	6.19	341	341	87	87	15	9	1	39.00	5.85	3.51
Cowiche Creek											
Sector 1	6.55	980	697	300	292	106	106	5	262.02	41.34	41.34
Sector 2	0.35	478	9	213	95	17	17	0			
Sector 3	32.85	4,612	3,094	1,227	845	334	324	71	7,969.14	130.26	126.36
Sector 4	25.03	30	30	21	21	80	0	1	60.00	31.20	0
Wide Hollow-Ahtanum											
Sector 1	20.73	760	760	298	298	194	30	58	2,426.28	75.66	11.7
Sector 2	70.72	39,621	4,052	13,345	3,565	1,092	779	256	8,066.23	425.88	303.81
Moxee											
Sector 1	49.18	14,991	4,575	4,819	3,735	1,073	511	44	26,099.91	418.47	199.29
Sector 2	11.52	205	205	134	134	46	37	0		17.94	14.43
Sector 3	43.52	461	461	38	38	29	12	10	196.00	11.31	4.68
Mabton											
Mabton	40.88	3,348	1,062	679	202	87	79	0	-	33.93	30.81
Rattlesnake Hills											
Sector 1	194.11	51,742	18,929	11,002	4,458	1,246	1,225	21	454,841.66	485.94	477.75
Sector 2	51.75	149	149	0	0	1	0	7	19.40	0.39	0
TOTALS	675.33	145,038	52,683	41,099	20,167	6,124	4,095	876	1,230,241.73	2,381.73	1590.42

1. Existing Residences defined as Residential land, Single/TwoToFour/FivePlus Unit and Vacation Home (County Assessor)

2. Buildable Lots defined as Residential land, Undeveloped (County Assessor)

Upper Naches

The Upper Naches Domain encompasses relevant lands upstream of the mouth of the Tieton River and includes the Bumping River (fig. 6). This domain covers 11.42 square miles of private lands (Table 1). Information analyzed for this domain included: fish presence, diversions, RLU parcels, surficial geology, and land ownership.

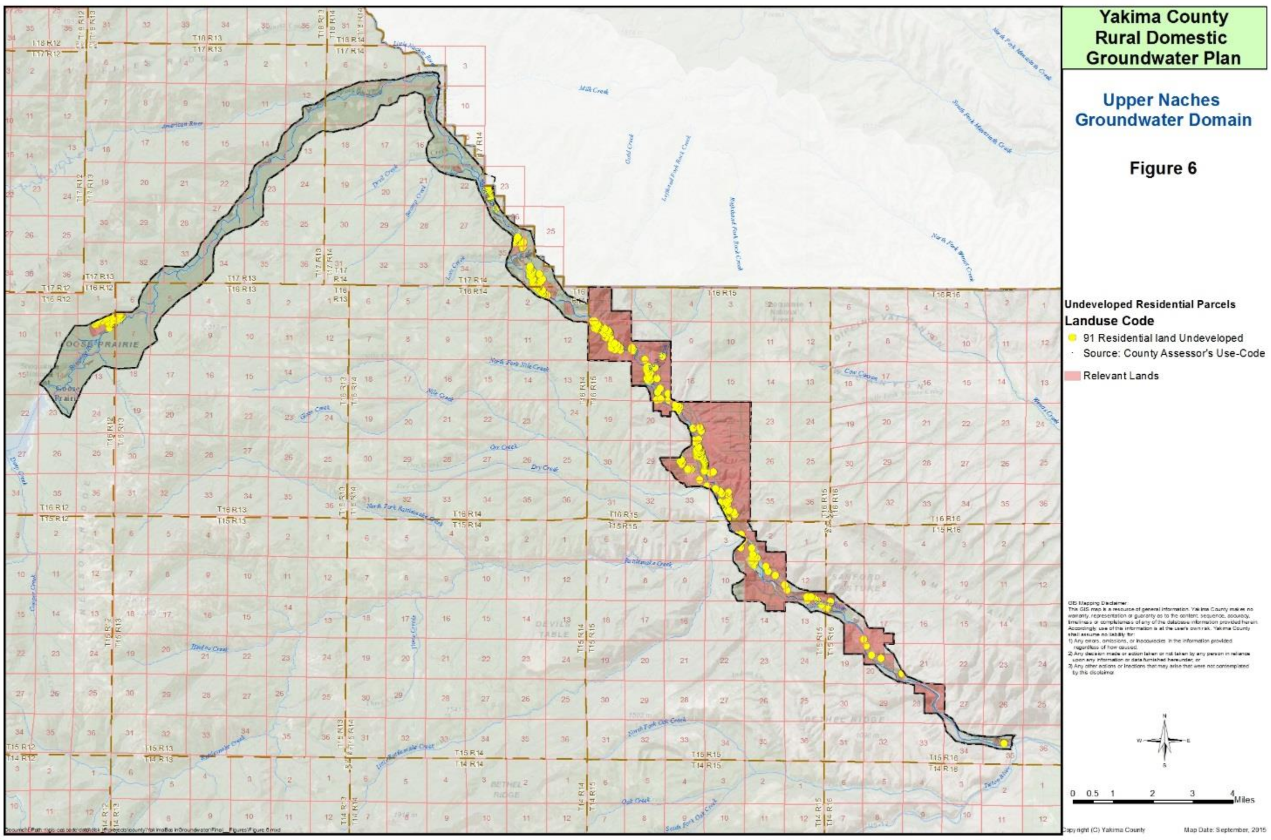
Bumping River is included in this domain for planning purposes because the RLU parcels (all located at Goose Prairie and likely vacation residences) are isolated from any tributary streams with documented fish presence. With only small storage in Bumping Lake and only 4 small diversions, the stream system is nearly unregulated with minimal diminishment of summer flows during dry years due to reservoir releases, especially during ‘flip-flop’ on the Naches arm. Consumptive use for future growth on the Bumping arm would at most be about 0.01 cubic feet per second or about 7.24 acre-feet.

The remaining part of the Upper Naches Domain includes relevant lands within the drainage area of the Naches River above the mouth of the Tieton, but does include lands in the Nile, Dry, and Rattlesnake Creek drainage areas. The fish presence layers indicate that in two tributary locations in the domain, lower Gold Creek and part of Rock Creek, that fish may be present. However, fish passage into Gold Creek is currently blocked and steep gradients in Rock Creek also may block fish passage; these aspects would need to be verified. For those two locations if fish are present, new wells drilled to at or below the level of Naches

River (finished in either the Grande Ronde unit or Tertiary units) would capture water moving to the river. In the Rock Creek drainage there are only three small diversions, and the RLUs are below two of these diversions, suggesting there would be no impact on them. The third, small diversion is closer to the mouth of the creek and deeper, new wells below the Naches River level could mitigate for creek impact, especially with the 74 percent septic-return flow.

Diversions (95) in the Upper Naches Domain total 54,653 acre-feet (about 75 cubic feet per second) [Table 1]. With the natural flow from the American and Little Naches Rivers and the nearly unregulated flow from Bumping River, surface water diversion demands have been met in drought years. These diversions are dominated by the Naches-Selah Irrigation District (NSID), and the Yakima-Tieton Irrigation District. The NSID diversion is located just above the confluence with the Tieton. Over half of the water diverted by NSID (110 to 130 cubic feet per second) is exported from the Naches watershed to the agricultural lands surrounding Selah, where natural perennial streams did not exist. Return flows and spill from the NSID eventually reaches the Yakima River above Selah Gap. The YTIP diversion is located at approximately river mile 17 on the Tieton River. All of the water diverted by the YTID (approximately 300 cubic feet per second) is exported from the Naches Basin, the majority of the water is sent to the adjacent Cowiche Creek Basin, with a much smaller amount heading to the Wide Hollow Basin, also an area where natural perennial streams did not exist (Ecology 2014, YCFZD 2012) Total consumptive use by RLU parcels would be about 0.04 cubic feet per second (about 30 acre-feet) [Table 1], with about 0.12 cubic feet per second (87 acre-feet) being returned to the shallow system as return flow. If the wells are shallow with a direct connection to the stream, the annualized values would obviously vary over the year, with larger potential impacts during the summer months. The actual effects also would be predicated on whether any new building was for vacation homes or permanent residences.

Figure 6. Location of Upper Naches Domain and residential land, undeveloped parcels.



Nile Creek

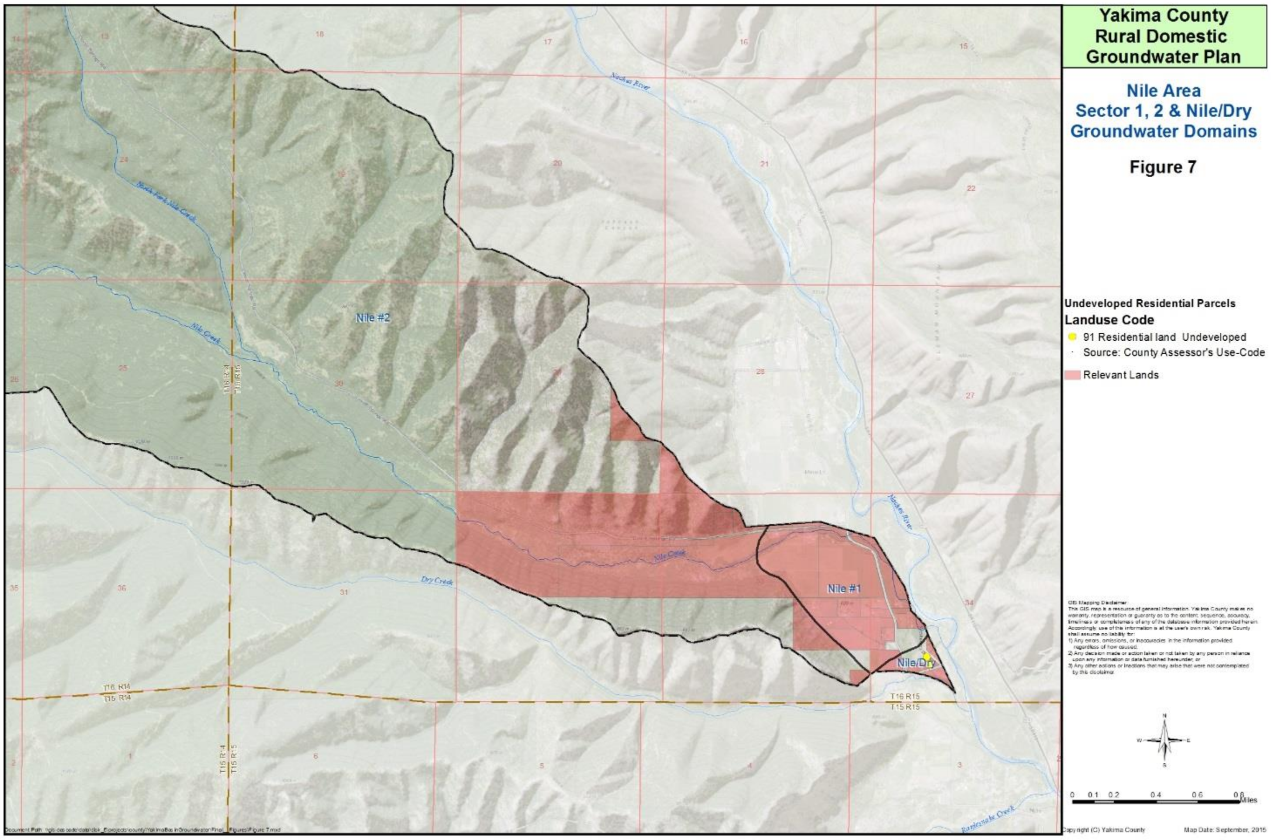
The Nile Creek Domain includes all of the relevant lands within its drainage area, but also includes a third sector termed the Nile/Dry Sector (fig. 7); the domain encompasses 1.1 square miles of private lands (Table 1). Information analyzed included: surficial geology, extent of hydrogeologic units, diversions, RLU parcels, land-surface altitude, and fish presence. As defined, there are currently two RLU parcels within its area and nine diversions--most of which are small and one large (fig. 4).

The domain includes three sectors that are mainly based on land-surface altitude, and proximity to the Naches River. Sector 1 encompasses most of low-lying lands in the basin. Pumpage from wells finished below the altitude of the Naches River and into the Grande Ronde unit would affect the river because groundwater levels in the deeper Grande Ronde unit tend to the altitude of the regional discharge area—the Naches River. Mitigation strategies would mainly involve main stem water.

Sector 2 is the upper part of the Nile Creek drainage (fig. 7), and new pumpage in this area (even from wells finished below the altitude of the creek) may affect the creek. There are no RLUs entirely within this sector, wells on these parcels should be drilled in other sectors of the Nile Drainage.

The Nile/Dry sector (fig. 7) was defined by the general land-surface altitude in this flat-lying area that abuts the Naches River. Groundwater in this area may be moving directly to the Naches River. The 2 RLU parcels in this domain are in this sector, which has one small diversion. Pumpage from wells finished in the Grande Ronde unit in this area would mainly affect the Naches River due to its proximity. The deeper the wells are finished below the river level, the more they would intercept water moving (typically upward) to the Naches River and not the creek. In addition, well data shows that water levels from some wells are at the level of the Naches River. Mitigation strategies for these few parcels may be oriented towards main stem flows.

Figure 7. Location of Nile Creek Domain and residential land, undeveloped parcels.



Dry Creek

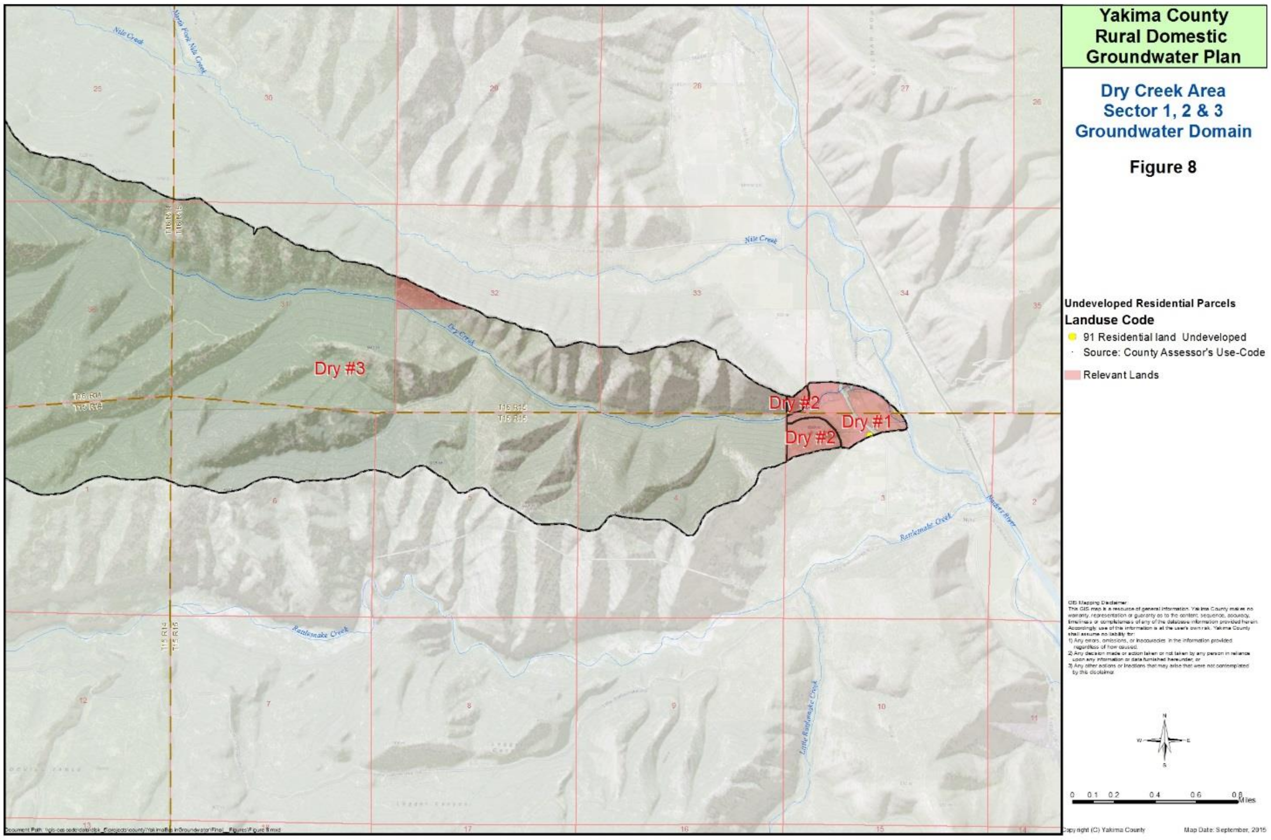
The Dry Creek Domain includes all of the relevant lands within its drainage area (fig. 8); these lands total 0.17 square miles (Table 1). Information analyzed for this domain included: surficial geology, extent of hydrogeologic units, diversions, RLU parcels, land-surface altitude, and fish presence. Within its area, there is currently one RLU parcel and three small diversions.

The domain was divided into three sectors (fig. 8) based on location of private lands, land-surface altitude, and proximity to the Naches River. Sector 1 includes the flat, low-lying part of the basin and contains the one RLU parcel. This sector is in close proximity to the Naches River. Drilling of wells finished in the Grande Ronde unit and some 50 feet or more below the altitude of the Naches River would result in pumpage effects mainly propagating to the Naches River and not the creek. Shallow groundwater (during the ‘wet’ season) would have a local pattern that is different from the deeper Grande Ronde unit system that would tend to a level of the sub-regional discharge area—the Naches River. Mitigation strategies may mainly be oriented to main stem water.

Sector 2 is in the steeper uplands bordering sector 1. Pumpage effects likely would be propagated to the creek if it is flowing. However, there are no RLU parcels or diversions in the defined area.

Sector 3 in this domain is the small piece of private lands (0.03 square miles) in the uplands (fig. 8). Similar to sector 2, pumpage effects may be propagated to the creek. There are currently no RLU parcels in this sector.

Figure 8. Location of Dry Creek Domain and residential land, undeveloped parcels.



Rattlesnake Creek

The Rattlesnake Creek Domain includes the 0.78 square miles of relevant lands within its drainage area (fig. 9). Information analyzed for this domain included: surficial geology, extent of hydrogeologic units, diversions, RLU parcels, land-surface altitude, and fish presence. Within its area, there are currently 10 RLU parcels, 24 small diversions, and one larger diversion.

The domain was divided into four sectors (fig. 9). Sector 1 includes the flat, low-lying part of the basin, contains 9 of the 10 RLU parcels (0.0013 cubic feet per second consumptive use, about 0.94 acre-feet), and has 7 diversions totaling 201 acre-feet (Table 1). This sector is in close proximity to the Naches

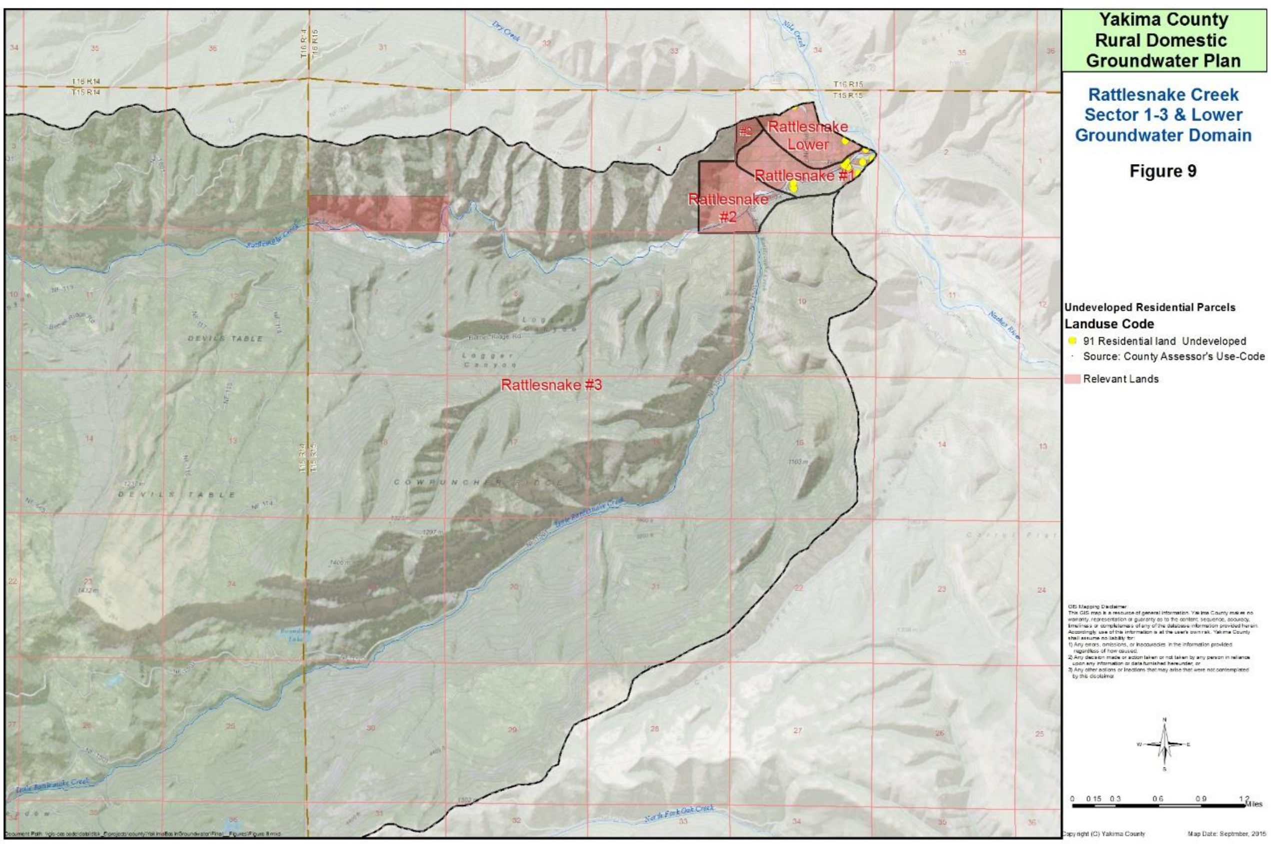
River. Drilling of wells finished in the Grande Ronde unit and some 50 feet or more below the altitude of the Naches River would result in pumpage effects mainly propagating to the Naches River and not the creek; the sub-regional groundwater flow would be moving to the Naches River with a predominant upward flow component. Similar to the Nile and Dry Domain's sector 1, mitigation strategies could mainly be oriented to main stem water.

Sector 2 is in the steeper uplands bordering sector 1. There are no RLU parcels and 1 diversion in this 0.22 square mile sector (Table 1). Pumpage effects likely would be propagated to the creek. Potential impacts of pumpage of a few residences would be well less than one percent of the natural flow of the creek and if this occurs, the mitigation could be oriented to the purchase of a small quantity of water from the 25 diversions in this sector.

Sector 3 is the rectangular area of private lands in the uplands (fig. 9) that encompasses four large parcels totaling 0.24 square miles. Similar to sector 2, pumpage effects likely would be propagated to the creek, which has fish presence in this area. However, development is unlikely to occur in this sector.

The fourth sector, the Lower Rattlesnake sector (so termed to distinguish it from the other sectors (similar to previously discussed Nile/Dry sector), [fig. 9] was defined by the general land-surface altitude in this flat-lying area that abuts the Naches River. Groundwater in this area would be moving directly to the Naches River. There is only one existing RLU parcel (about 0.00014 cubic feet per second consumptive use, or about 0.1 acre-feet) in this sector and no diversions. Pumpage from wells finished in the Grande Ronde unit would mainly affect the Naches River due to its proximity, and most Grande Ronde groundwater levels will trend to the Naches River level. The deeper the wells are finished below the river level, the more they would intercept water moving to the Naches River and not the creek. In addition, well data shows that water levels from some existing wells are at the level of the Naches River. Mitigation strategies could be oriented towards main stem flows.

Figure 9. Location of Rattlesnake Creek Domain and residential land, undeveloped parcels.



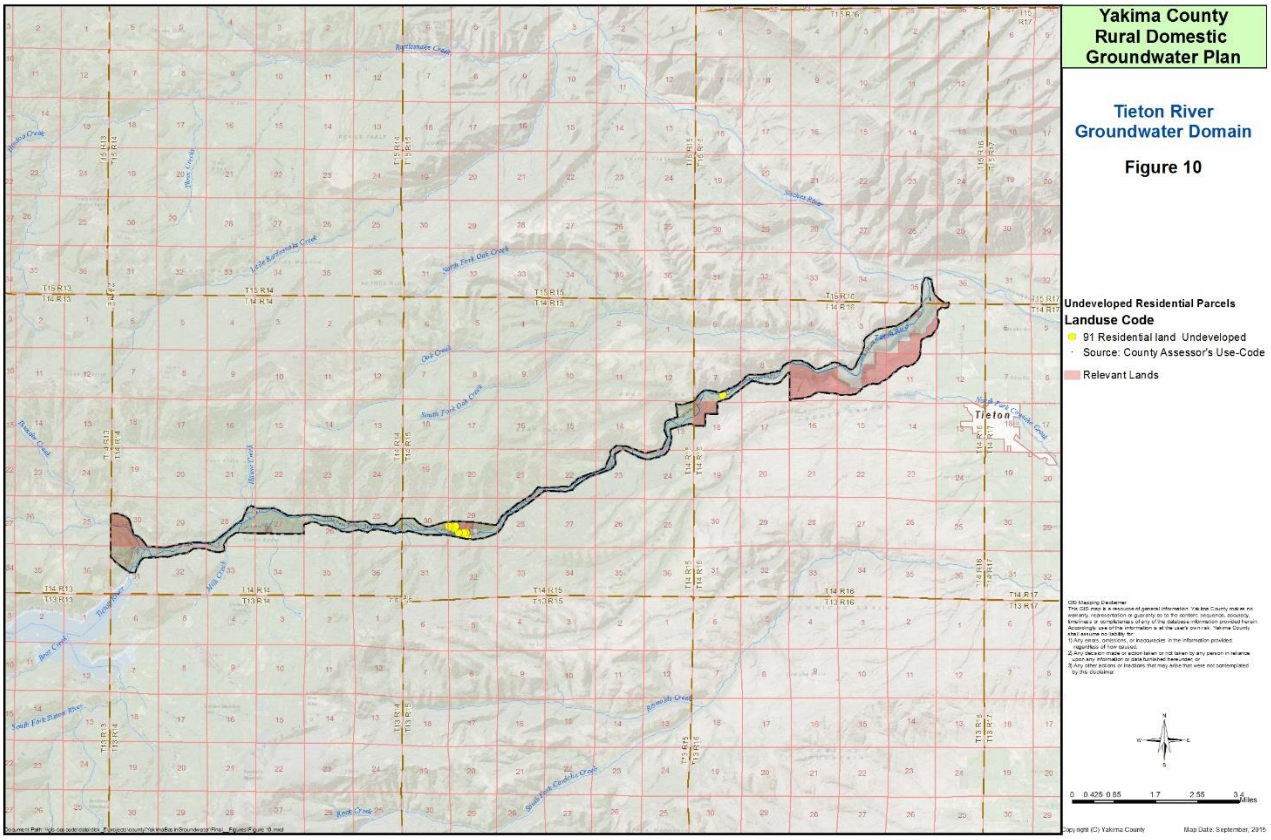
Tieton River

The Tieton River Domain includes all of the relevant lands in the drainage area of the Tieton River (fig. 10). Private lands in this domain only encompass 1.97 square miles with 13 RLU parcels. Information analyzed included: surficial hydrogeology, fish presence, land ownership, and diversions.

There are 17 diversions with an allowable 107,371 acre-feet but only four lie in the domain. Most of the other 13 diversions are small ones located in the uplands on USFS lands. The largest of the four in the domain proper is for the Yakima-Tieton Canal. The remaining three diversions are all small and only one is in the lower part of the river system. Two of the diversions are on a small parcel of private land that is surrounded by USFS lands in the uplands on the south side (right bank) of the river. Of the 13 RLU parcels in this domain, two are in the lower part of the river system. Most of the remaining parcels are congregated on private lands below the Yakima-Tieton diversion and likely would be vacation residences. There would be minimal impact on streamflow from consumptive use--less than 0.005 cubic feet per second (perhaps higher during the summer months if outdoor watering occurs). Less than 0.02 cubic feet per second bypassed from Tieton diversion (well less than measurement error), would meet future demand and provide additional water to the river for habitat and fish use. During ‘flip-flop’, any pumpage effects would not be measurable.

Pumpage effects will all be on main stem Tieton River and would be mitigated with main stem water.

Figure 10. Location of Tieton River Domain and residential land, undeveloped parcels.



Lower Naches River

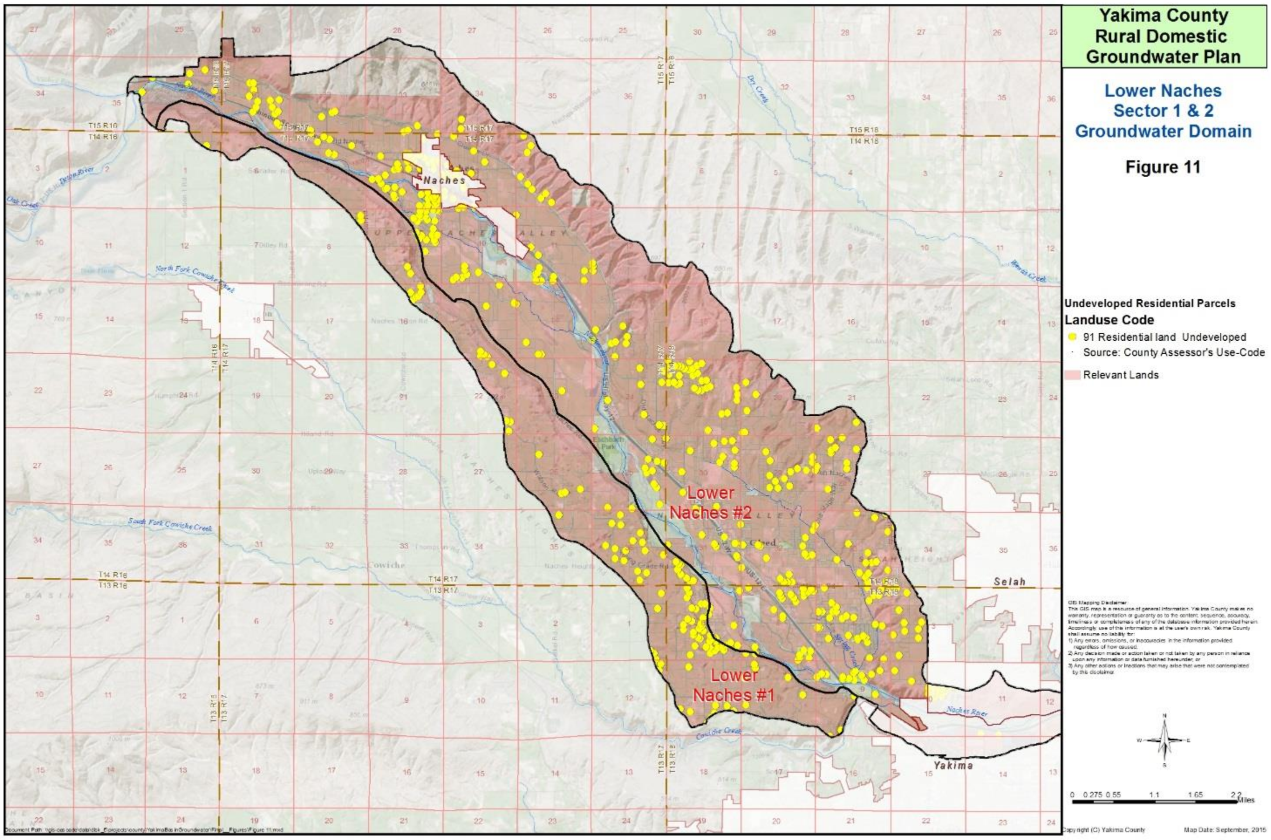
The Lower Naches River Domain (32 square miles) includes all of the relevant lands in the Naches River drainage area below the Upper Naches and Tieton River Domains (fig. 11). For this domain, groundwater levels and extent for the basin-fill deposits, Saddle Mountains unit, and the Wanapum unit were analyzed. Other information analyzed included: land ownership, diversions, fish presence, surficial hydrogeology, geologic structure, well logs, location of irrigation districts, and RLU parcels.

This domain has 112 diversions with an allowable quantity of 117,709 acre-feet. Over half of this water is exported out of the Naches Basin to the urban and agricultural areas surrounding the city of Yakima, and other portions of the Wide Hollow drainage. There are 486 RLU parcels (all but 11are in irrigation districts) representing a potential consumptive water demand of 0.07 cubic feet per second (about 49 acre-feet) [Table 1]. For this domain, mitigation strategies are oriented to main stem water.

The domain has two sectors. Sector 1 is on the right bank, south of the alluvial valley (fig. 11), where the surficial geology generally is defined by the extent of the outcropping andesite geologic unit. There are 108 RLU parcels in this sector indicating a total demand of 0.058 cubic feet per second or 42 acre-feet, about 10.8 acre-feet consumptive use. Future well construction may be dictated by approaching the altitude of the Naches River. Well depths could be based on the altitude of Naches River (by straight line from a well point) or based on penetration of the fine-grained Mabton unit that is present in this area (the latter likely not necessary). For this sector, many of the existing wells are at or below the level of the river and most pumpage impacts would be on the Naches River. The depths of the existing wells appear to be related to a well's location relative to depth of the contact between the andesite and the basin-fill deposits (typically the historical Naches River floodplain deposits). The low quantities of precipitation and thus, recharge in this steep sector indicates why many wells are drilled deep to find water. Of the 23 diversions in this sector, there are 10 small diversions at the bottom of the andesite bluff abutting the river; these diversions are congregated in the eastward part of the sector and some may be spring fed at the contact between the andesite and basalt/basin-fill deposits. Groundwater levels indicate that flow is towards the Naches River in this sector.

Sector 2 encompasses the remaining part of the domain and includes the area on the left bank that is not in the alluvial valley (an upland area) that has groundwater moving towards the Naches River. There are no diversions or streams with fish presence in this upland area, and parts of it are developed with residential housing. The pumpage effects of any new wells, regardless of depth, would be propagated to the Naches River. Of the 378 RLU parcels in this sector, all are in irrigation districts. Future water demand for this sector would be on the order of 0.2 cubic feet per second or 147 acre-feet or about one-hundredth of a percent of the diversions.

Figure 11. Location of Lower Naches Domain and residential land, undeveloped parcels.



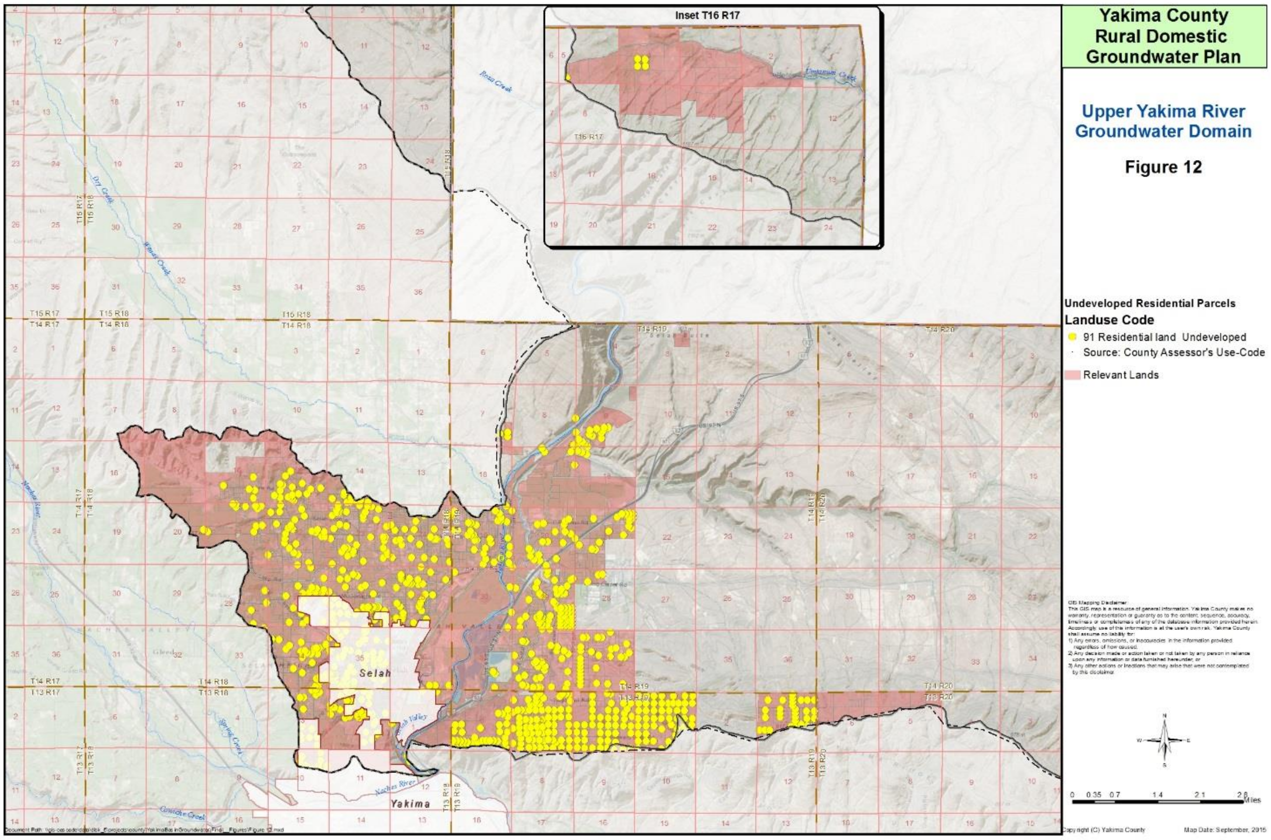
Upper Yakima River

The Upper Yakima River Domain (fig. 12) includes all relevant lands that drain to the Yakima River and are upstream of the mouth of the Naches River. Much of this domain corresponds to the Selah structural basin of Jones and others (2006), and groundwater recharge is strongly effected by irrigation water imported into the basin by the Naches Selah Irrigation District. However, it does not include the Wenas Creek basin. Thus, the domain is from the northern Yakima County line downstream to the mouth of the Naches River as defined by the Lower Naches Domain. Groundwater pumpage effects would not propagate below this domain due to geologic structure that acts as a flow barrier at the Selah Gap.

The domain includes all of relevant lands in what WDOE Scoping Map labeled as sub basins 6, 10, 11, and 12. For WDOE's sub basin 5, it would include lands above (north) of the topographic high of Yakima Ridge. The total relevant lands in this domain encompass 32.6 square miles with 726 RLU parcels, of which 431 are in irrigation districts. There are 20 diversions with an allowable quantity of 433,804 acre-feet. The estimated future demand (0.4 cubic feet per second or 283 acre-feet) is about 6 one-thousandths of a percent of the diversion quantity in this domain. Mitigation strategies for this domain are oriented to main stem water.

WDOE's sub basin 6 was defined by the drainage areas between the Naches River and Wenas Creek. It is recognized that, based on basin-fill groundwater levels, some of its groundwater moves to the Naches River. However, this discharge is near the mouth of the river and within the structural basin, and thus, its complete extent was included in this domain. Almost all of any potential pumpage effects would be oriented to near the confluence of the Naches and Yakima Rivers above Selah Gap.

Figure 12. Location of Upper Yakima River Domain and residential land, undeveloped parcels.



Wenas Creek

The Wenas Creek Domain (48 square miles) includes all relevant lands within its drainage area (fig. 13). For this domain, groundwater levels and extent for the basin-fill deposits, Saddle Mountains unit, the Wanapum unit, and the Grande Ronde unit were analyzed. Other information analyzed included: land ownership, diversions, fish presence, creek elevation, surficial hydrogeology, depth to the top of the Saddle Mountains and Wanapum units, geologic structure, well logs (geology and elevation of and depth to groundwater level), hydrogeologic sections, location of irrigation districts, and RLU parcels.

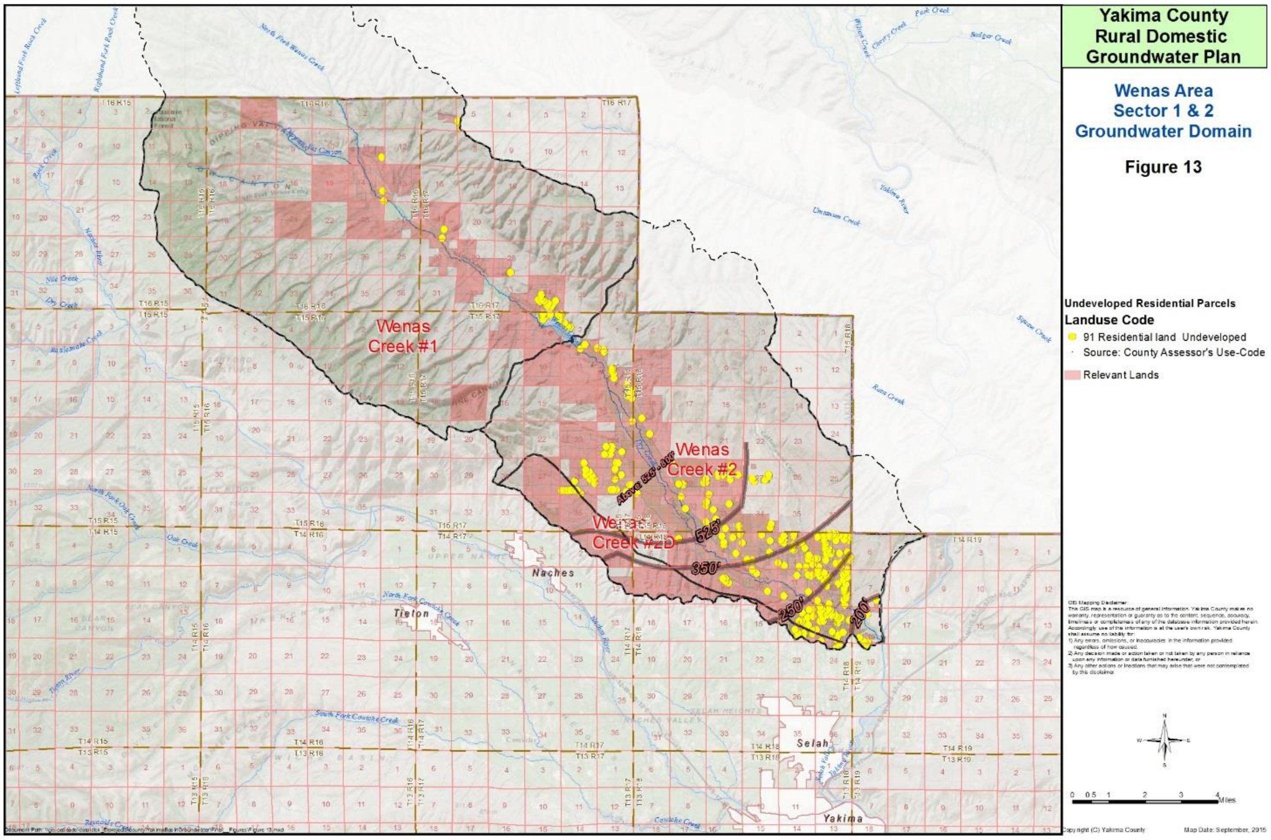
The domain was divided into 2 sectors (fig. 13). Sector 1 is the drainage area for Wenas Dam and encompasses about 13.8 square miles. There are 31 RLU parcels in this sector (consumptive use of about 0.0034 cubic feet per second or 2.4 acre-feet) and 19 diversions in this sector with an allowable quantity of 2,016 acre-feet. Wells drilled to depths similar to some of the existing wells may have the pumpage effects mainly propagated to the creek, particularly in the upper part of the sector where most wells are shallow with corresponding shallow groundwater levels. However, various wells located just north and northeast of Wenas Dam are deeper and their water levels vary from about 100 to more than 400 feet below land surface. A few existing deep wells near the creek in this area have water levels more than 300 feet below creek level—suggesting downward flow. Twenty-four of the 31 RLU parcels in this sector are in this area. Development of a Group A system to supply water and share the costs of drilling of a deep well may be cost effective. A well drilled some 600 to 900 feet deep below the tighter Vantage Interbed unit into the Grande Ronde unit would capture mainly sub-regional to regional flow as the well elevation would approach the elevation of the creek at its mouth. Although impeded by the extent of the Vantage unit and basalt flow interiors, if there is increased vertical downward leakage from any head declines propagating above the Vantage due to the pumpage, it would be more spatially spread out—allowing for any potential in-basin water right purchases also to be more spread out. In addition, about 0.012 cubic feet per second (8.9 acre-feet) would be returned to the shallow system.

Sector 2 is the remaining drainage area of the relevant lands in the Wenas Creek drainage area. This sector totals about 34 square miles of private lands with 251 RLU parcels (69 in irrigation districts). There are 103 diversions with an allowable quantity of 14,775 acre-feet, none of which is exported from the Wenas basin. The long-term build-out consumptive use of the 251 parcels (about 25 acre-feet) would be about twentieth of one percent of this quantity. For this sector, contours for suggested future well depths were drawn based on the extent of the basalt units and the thickness of the extensive fault-controlled basin-fill deposits in the upper part of this sector. The suggested well depths are principally based on: 1) the depth to the top of the Wanapum unit, 2) the depth to the top of Saddle Mountains in the lower part of the sector, and 3) the approximate elevation of the lower part of Wenas Creek. For example, the 550 foot well-depth contour closely follows the 800 foot depth to top of Wanapum unit. Future wells finished at this depth would be finished in the lower part of the thick basin-fill deposits or perhaps (depending on location) in the upper part of the Wanapum unit. Such wells would penetrate either the Saddle Mountains or Wanapum units in the lower part of the sector or deep into the basin-fill deposits further up gradient. Similarly, the 200 foot well-depth contour in the eastward part of the sector would penetrate basalt units and be below the level of the Yakima River. In Township 15-Range 13 section 13, the basin-fill deposits thin from about 1,000 feet to 600 feet in thickness and by section 12 the deposits thin to 200 to 400 feet in thickness. Thus, starting in the upper part of section 13, the remaining up gradient part of this sector would have wells penetrating the Wanapum unit. Note that various existing wells in the thick section of basin-fill deposits in the upper part of this sector (some 2 miles below Wenas Dam) are already drilled deep, some to more than 800 feet because these deposits are poorly permeable.

The small consumptive demand and the suggested well depths indicate mitigation strategies may be oriented to both main stem water and/or purchase of in-basin rights. The small consumptive use relative to diversion quantities suggests in-basin purchases may be a viable option. In-basin purchases would mean that future well depths could be less than the suggested depths; the suggested depths were estimated such that future pumpage effects would principally but not totally propagate to the Yakima River and not Wenas Creek. For in-basin purchases, shallower wells should generally be more than 100 feet deep to minimize potential contamination from land-surface activities. The number of future shallower wells would be predicated on the quantity of in-basin water purchases.

This sector has a subdivision (called sector 2D, fig. 13) based on Wanapum unit groundwater levels (Vaccaro and others, 2009) that suggest a groundwater divide. This subdivision is separated from sector 2 in Table 1 for reference purposes. Pumpage effects from wells in this part may mainly propagate outside the basin to the Naches or Yakima Rivers if this divide is controlled by geologic structure. If the divide is mainly oriented to hydraulics, pumpage effects could propagate into the basin. Except for the most downstream part of 2D, there are few (15) RLU parcels in this subdivision.

Figure 13. Location of Wenas Creek Domain and residential land, undeveloped parcels.



Cowiche Creek

The Cowiche Creek Domain (fig. 14) includes all relevant lands (64.8 square miles) within the Cowiche Creek drainage area. Information analyzed for this domain were land ownership, mapped groundwater levels for the basin-fill deposits and the three basalt units, diversions, RLU parcels, fish presence, surficial geology, extent of hydrogeologic units, geologic structure, mapped hydrogeologic sections, and well data.

The domain was divided into four sectors (fig. 14). Sector 1 (6.55 square miles) is in the northeast part of the basin (fig. 14), and its divide from the remainder of the basin was based on Saddle Mountains and Wanapum unit groundwater levels. Further to the northeast and outside the basin near the Naches River along the base of the mapped extent of the geologic andesite unit is a mapped synclinal fold (Jones and others, 2006; Jones and Vaccaro, 2008). In the Yakima Fold Belt, such folds generally are associated with an anticline. The groundwater levels suggest the presence of an anticline that would act as a flow barrier. Pumpage effects likely would not propagate across this barrier. Given the shallow infiltration of excess surface water from the delivery and application of imported irrigation water in this area, the groundwater levels further indicate the presence of a flow barrier. In addition, the location of the andesite unit further suggests that there is an anticline. Thus, the groundwater levels showing flow towards the Naches River suggest that pumpage effects, especially from deeper basalt wells would be outside of the basin and experienced by the Naches River. Depending on location future wells would be finished in either the Saddle Mountains or Wanapum unit, with the Wanapum unit being the major unit for supplying future groundwater supply. Mitigation strategies likely could mainly involve main stem water for this sector. There are 106 RLU parcels (consumptive use of about 11 acre-feet) and five diversions with an allowable quantity of 262 acre-feet in this sector. All of the RLU parcels are in the Yakima-Tieton Irrigation District.

The small sector 2 (fig. 14) represents a 0.35 square mile area where basalt groundwater levels indicate flow is moving outside of the basin and does not discharge to the creek. This sector also includes a small part of relevant lands that are imbedded within the city limits of Yakima, including a very small area within the Wide Hollow Creek drainage area. These areas were best combined with this sector because groundwater flow would be towards the Yakima River and any future pumpage effects would not be propagated to tributary creeks. The sector includes 17 RLUs and all of them are within an irrigation district. Wells drilled to and finished in the local basalt unit in a particular area (that is, depending on location, that unit may be any one of the three basalt units) to below the altitude of the Naches River would have the largest effect on the Naches River and not on the creek. Like sector 1, mitigation strategies could be oriented to main stem water.

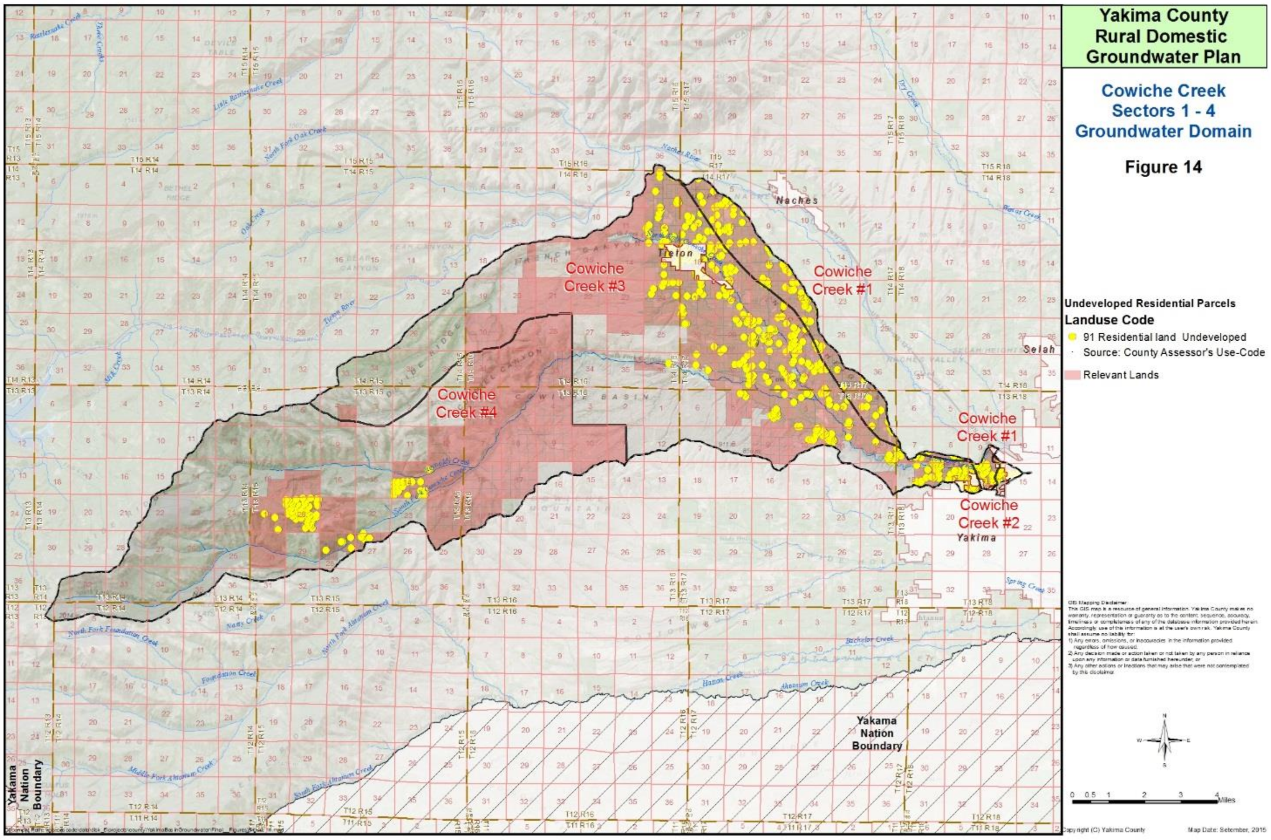
Sector 3 (32.9 square miles) is oriented to the northern and northeast part of the basin (fig. 14). There are distinct differences in groundwater levels between the basin-fill deposits and the basalt units in this sector. In turn, groundwater levels in deeper basalt wells also show differences from shallower basalt wells. Groundwater levels in existing deeper wells are well below creek level (unlike those in the thin, shallow basin-fill deposits) and may be locally detached from the shallow system as driller logs indicate no water producing zones in parts of the upper basalts or consolidated units (such as sandstone). Tighter geologic material higher up in this sector may separate well effects propagating to Cowiche Creek. Some wells are artesian suggesting adequate separation, but at some point (likely towards the headwaters outside of private ownership) these aquifers are recharged and have direct connection to the creek. The deeper basalt wells are drilled to near the altitude of the Naches River or below, and their water levels are well below creek level. Wells drilled 350-600 feet deep (shallower depths lower in the watershed and deeper depths higher in the watershed-for example, near the City of Tieton) and finished in basalt may be locally detached from the creek but can potentially capture some down gradient discharge. This effect would be minimized if all new wells for the 334 RLU parcels (about 34 acre-feet of consumptive use) are drilled to such depths in this sector. However, it should be noted that in parts of the County, many domestic wells are 350-600 feet deep. Overall, groundwater levels from varying well depths suggest the deeper system tends to the level of the Naches River. Wells in this sector would typically be finished in the Grande Ronde unit. Cost sharing for drilling of deeper wells can be shared by residences such as establishment of larger Group A systems. The purchase of existing deep irrigation wells in this sector may also be an option to avoid the costs of drilling a new deep well. It should be noted that with 71 diversions in this sector (allowable quantity of 7,969 acre-feet) in-sector purchase of water may be a viable mitigation option versus drilling of deeper wells because the estimated potential future consumptive use is less than one percent of the diversion quantity. The 334 RLU parcels also may have less future demand because all but 10 RLUs are in the Yakima-Tieton Irrigation District.

The upper part of sector 3 includes the drainage area for the North Fork Cowiche Creek above a small reservoir, which is primarily used by the Yakima-

Tieton Irrigation District to store or reregulate water diverted from the Tieton River. The North Fork has no documented fish presence in this area. There are currently no RLU parcels in this area and future development likely will be minimal. Any effects from future pumpage could be propagated to the section of the creek, which is dry most of the year. A small purchase of main stem water would mitigate for these effects.

Sector 4 (fig. 14) is in the part of the watershed where pumpage effects (even with deeper wells) could be propagated to the South Fork of Cowiche Creek. This 25 square mile area has documented fish presence. Explicit mitigation strategies would need to be defined in the future. Pumpage likely would be small in this sector from the 80 RLU parcels because total estimated demand would be only about 0.04 cubic feet per second (about 31 acre-feet) and consumptive use much less. Any potential flow diminishment would likely be well less than one percent of natural flow.

Figure 14. Location of Cowiche Creek Domain and residential land, undeveloped parcels.



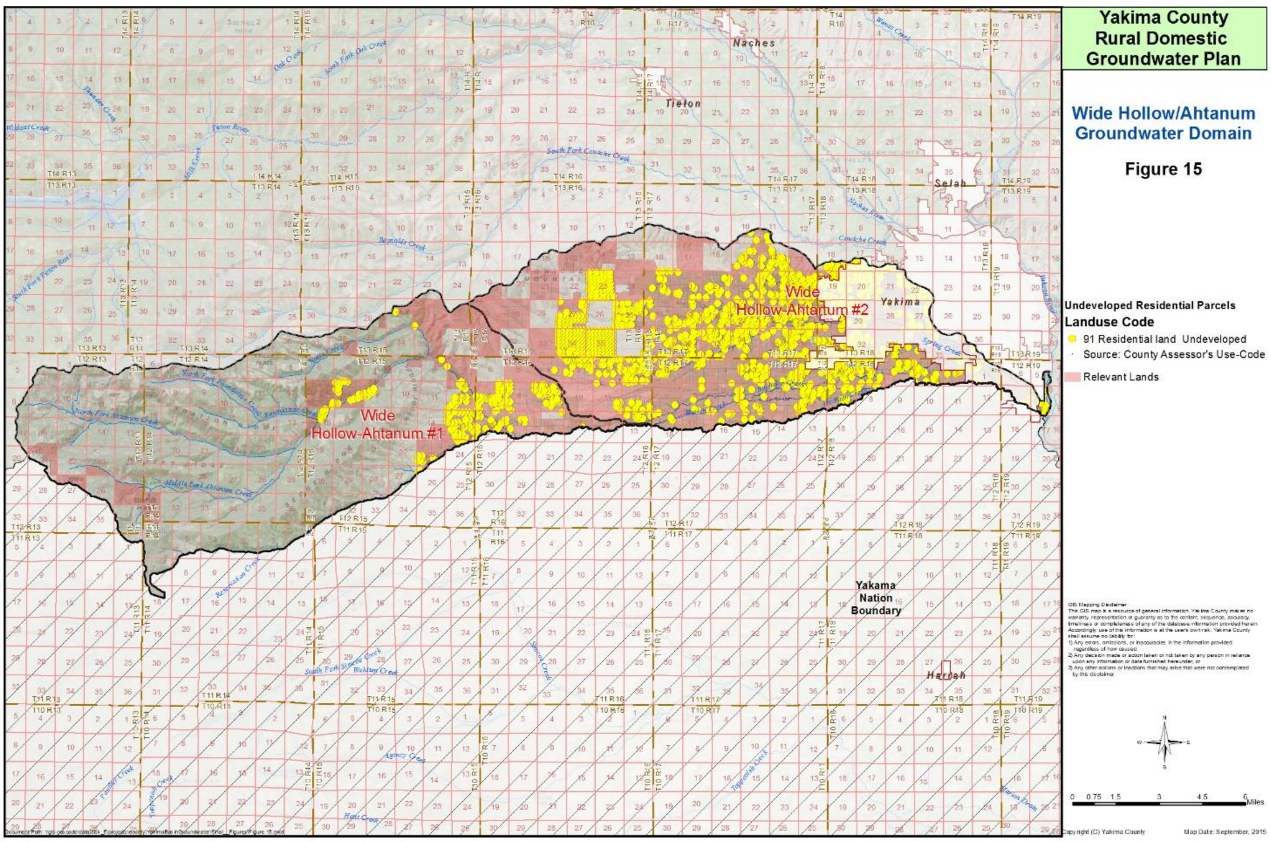
Wide Hollow/Ahtanum

The Wide Hollow/Ahtanum Domain (fig. 15) includes all relevant lands (91.5 square miles) within the Wide Hollow Creek drainage area and the Ahtanum Creek drainage area outside of the lands of the Confederated Bands and Tribes of the Yakama Nation. Lands within municipalities and the Nob Hill Water District, which contains 1,055 RLUs, are not included. The final domain analysis was not completed for this domain because of the on-going adjudication of surface water in the domain. However, an initial, preliminary analysis was completed for this domain and its sectors. This analysis will be reviewed by both YN and WDOE hydrogeologists in technical meetings/discussions. Any changes or suggestions from these meetings will be incorporated into the analysis. Upon completion of the adjudication process in this domain, the analysis will be added to this report.

Information analyzed for preliminary analysis were land ownership, mapped groundwater levels for the basin-fill deposits (and their subdivisions) and the three basalt units, diversions, RLU parcels, fish presence, surficial geology, extent of hydrogeologic units, geologic structure, mapped hydrogeologic sections, topography, and well data. The extent of the hydrogeologic units relative to creek elevations and groundwater levels in wells provided valuable information. Thickness of the hydrogeologic units relative to each other also provided good information for the preliminary analysis.

The domain was divided into two sectors. Sector 1 is the Ahtanum Creek drainage area (20.8 square miles) above what is termed 'the Narrows'. At the terminus of the Narrows, the creek debouches onto the floodplain composed of the mapped alluvial unit (Jones and others, 2006). Any pumpage effects upstream of the Narrows from 'shallow' basalt wells would impact streamflow above the Narrows and not below it. This sector defines a distinct drainage area (similar to other tributary basins) for only Ahtanum Creek. In addition, the area upstream of the confluence of the Nasty Creek and North Fork Ahtanum Creek is likely isolated from the South Fork Ahtanum Creek due to geologic structure. After that confluence, the North Fork follows a fault to where it meets the South Fork Ahtanum Creek. There are 194 RLU parcels (164 in irrigation districts) and 58 diversions (allowable quantity of 2,426 acre-feet) in this sector. Sector 2 begins at the terminus of the Narrows and encompasses 70.7 square miles. Within this sector there are 1,092 RLUs (779 of which are in irrigation districts) and 256 diversions with an allowable quantity of 8,066 acre-feet.

Figure 15. Location of Wide Hollow/Ahtanum Domain and residential land, undeveloped parcels.



Moxee

The Moxee Domain (104 square miles) includes the relevant lands over much of the Moxee Valley south of the Upper Yakima Domain (defined by the Yakima Ridge), north of Rattlesnake Hills, and west of the Black Rock/Cold-Dry Creek valley (fig. 16). The domain also includes a small sliver of relevant land west of the Yakima River (right bank) that is east of both the Yakima and Union

Gap municipalities. This small part of lands west of the river was included as part of the Moxee Domain and other areas in WDOE's Scoping Map. It is disconnected from the Wide Hollow/Ahtanum Domain and any effects of future pumpage would propagate to the Yakima River and not to any tributary creeks. The eastern boundary of the Moxee Domain was based on the analysis of Kirk and Mackie (1993), mapped water levels of Vaccaro and others (2009), hydrogeologic sections of Jones and others (2006), geologic structure, and watershed boundaries. In this complicated, structurally controlled area there are several faults and folds. Each of these structures may affect groundwater flow (eastward in contrast to westward flow direction or compartmentalization) in the hydrogeologic units differently (Kirk and Mackie, 1993). The boundary selected was based on the watershed boundary (principally defined by the crests of Yakima Ridge and Rattlesnake Hills), and is consistent with the concept of watershed boundaries for the other tributary basins. The boundary also is consistent with any ephemeral runoff draining to the Yakima River (or providing local recharge to the system) and the groundwater levels for the Saddle Mountains unit.

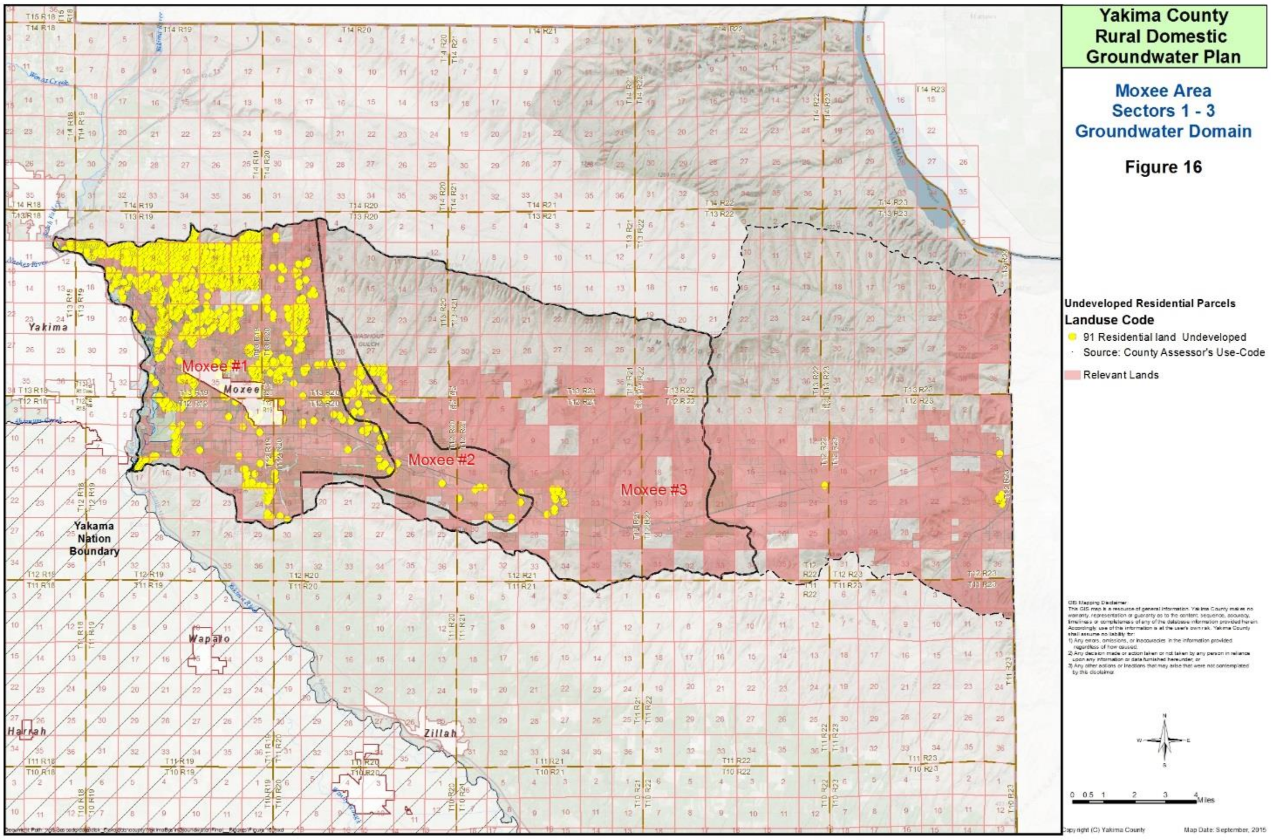
For this domain, groundwater levels and extent for the basin-fill deposits, Saddle Mountains unit, Wanapum unit, and Grande Ronde unit were analyzed. Other information analyzed included: land ownership, surficial hydrogeology, geologic structure, well logs, location of irrigation districts, groundwater-level hydrographs, recharge, aerial photographs, current zoning, and RLU parcels. Some of the information analyzed for this domain was oriented to obtaining a better understanding of the location and extent of groundwater-level declines in the valley because the domain included an ACA identified in WDOE's Scoping Map. The domain was divided into three sectors (fig. 16). Mitigation strategies for all sectors would be oriented to main stem water. The domain contains 1,763 RLU parcels of which 365 are in the Terrace Heights Water District and 560 are in irrigation districts.

Sector 1 (49 square miles) includes the small sliver of lands west of the Yakima River and the part of the Moxee valley that encompasses the Selah-Moxee Irrigation District and much of the Roza Irrigation District. The delivery and use of surface-water in these districts provide a source of recharge (more than 10 inches per year and in some areas more than 20 inches per year; Vaccaro and Olsen, 2007) to the system. The City of Moxee and the Terrace Heights Water district are in this sector. Except for the very peripheral steep uplands, the sector is typified by thick basin-fill deposits. Basin-fill deposits in are almost everywhere greater than 200 feet, and over much of this sector they are greater than 800 feet (in some areas greater than 1,200 feet). Most of the existing domestic wells are finished in these deposits and much of the future pumpage in this sector would occur from these deposits. Groundwater-level hydrographs indicate stable water levels in these deposits. The groundwater levels for the units indicate that future withdrawals from the sediments would have minimal, if any, affect, on the deeper Wanapum and Grande Ronde units. The sedimentary deposits thin in the steeper uplands near Yakima Ridge and Rattlesnake Hills where basalt outcrops. There about 9 standby/reserve groundwater-right wells in the Roza Irrigation District in this sector; many of these wells are deep and finished in the Wanapum or Grande Ronde units. Pumpage from these wells in dry years may have minimal impacts on water levels in the basin-fill units where most future residential wells will be finished in because of the low-permeability of the basalt flow interiors and the Mabton and Vantage Interbeds. There are about 1,073 RLU parcels in this sector (511 in irrigation districts) and 44 diversions with an allocable quantity of 26,100 acre-feet. Of the RLU parcels, 365 are in the Terrace Heights water distribution area, indicating about a 0.38 cubic feet per second (277 acre-feet) total future demand (not accounting for potential reductions for the RLUs in the irrigation districts) for the remaining parcels.

Sector 2 (11.5 square miles) abuts sector 1 to the east, and contains the remaining part of the Roza Irrigation District that is in the valley, which was not included in sector 1. There are 46 RLU parcels (37 are in irrigation districts) and no diversions in this sector. This entire sector is underlain by basin-fill deposits, some of which are greater than 600 feet in thickness. Existing domestic wells typically withdraw water from these deposits. On the peripheral edges of the sector where the deposits are thinner, future wells may need to extend into the basalts. WDOE recommends (J. Kirk, Washington State Department of Ecology, oral communication, 2015) that future residential wells be finished in the upper part of the Saddle Mountains unit. However, there is no current (2015) requirement of the hydrogeologic unit for a new exempt well, but wells finished in the upper part of the Saddle Mountains unit would be less prone to experience groundwater level declines over time. For planning purposes, a map showing the depth to the top of the units is available at *http://pubs.usgs.gov/sir/2008/504* (plate 1 download). There about 6 standby/reserve groundwater-right wells in the Roza Irrigation District in this sector; most of these wells are finished deep into the basalts. Historical groundwater level information suggests that declines deeper in the system are not propagated upwards to the same extent due to the semi-confining to confining units present throughout the deeper system, especially because some sub-units within the basin-fill deposits are very ‘tight’.

Sector 3 (43.5 square miles) is the remaining part of the relevant land in the Moxee Domain. This sector only receives small amounts of recharge (Vaccaro and Olsen, 2007) and the upstream groundwater contributing area to wells is small. Most of this sector is zoned for agricultural lands and WDOE is not issuing new groundwater irrigation rights in this sector. There are 29 RLU parcels in this sector (12 in irrigation districts). Thus, development in this sector will likely be minimal. Parts of the sector are underlain by basin-fill deposits and in other parts, especially along the uplands, it is underlain by the outcropping Saddle Mountains or Wanapum unit (the Wanapum unit only outcrops over about 1 square mile in this sector). Depending on location, existing domestic wells in this sector are finished in either the basin-fill deposits or basalts. Basin-fill deposits in this sector are patchier and thinner than in sectors 1 and 2. Most of the documented declines in groundwater levels have occurred in the Wanapum and Grande Ronde units. Thus, it may be best if future pumpage from domestic wells in this sector occur from either the sediments or to what Kirk and Mackie (1993) called the upper Saddle Mountains aquifer. This part of the aquifer receives direct recharge where it outcrops as evidenced by seasonal water-level changes. The bottom of the aquifer was defined as the Rattlesnake Ridge Interbed, whose surface has not been mapped. No explicit well depths are defined and if they were, there would be no guarantee that a well would penetrate a water-producing zone for a depth because there is little information on wells and water levels over much of this sector. Future development in this sector needs to be aware that it may be prone to declines due to increased pumpage. There are several permitted groundwater-irrigation wells in this sector; most (but not all) of these wells are very deep (greater than 1,000 feet) basalt wells. It is unknown to what extent pumpage from these wells can affect water levels in the shallower system where exempt wells would withdraw water from. Observed data in parts of the Columbia Plateau aquifer system, which the Yakima River basin aquifer system is part of, suggests pumpage affects from deeper in the system may have minimal effect on the shallow system.

Figure 16. Location of Moxee Domain and residential land, undeveloped parcels.



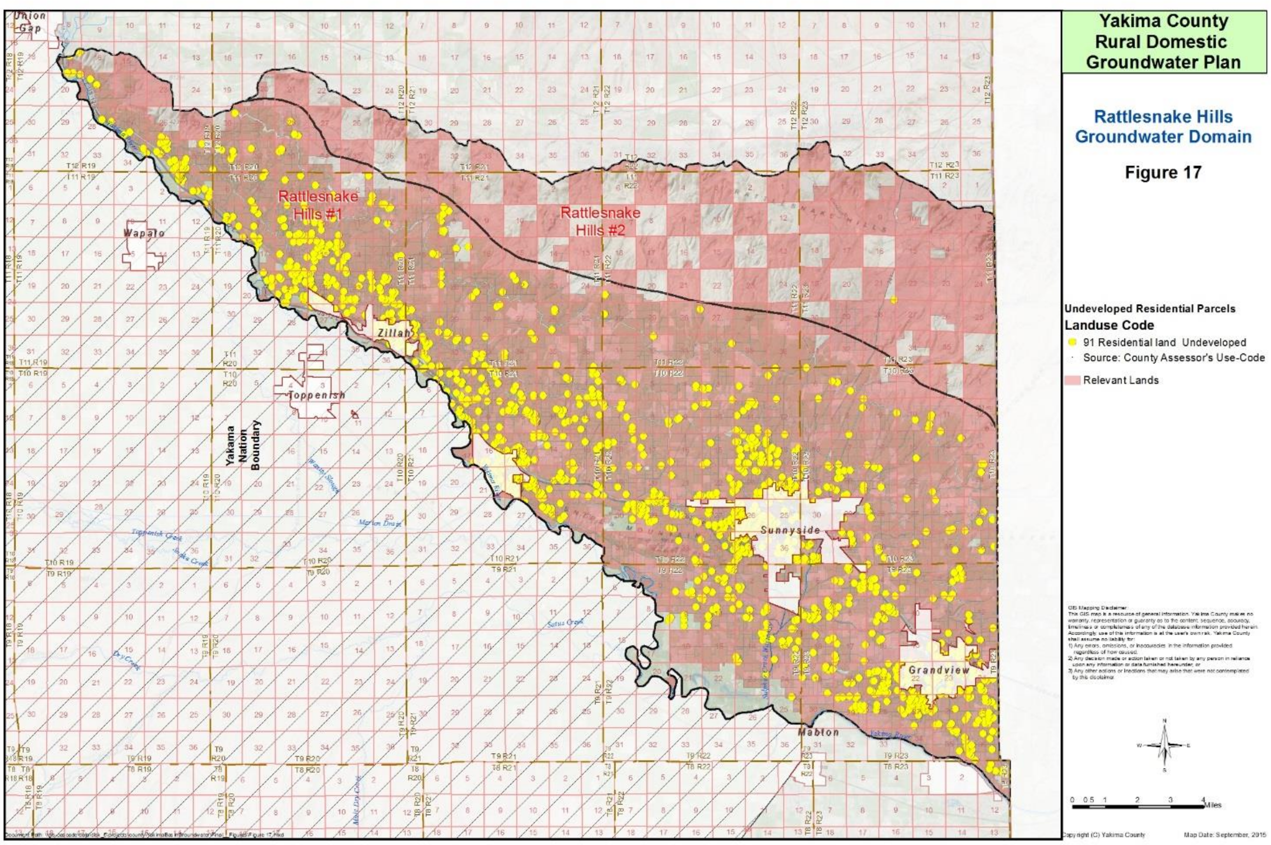
Rattlesnake Hills

The Rattlesnake Hills Domain (246 square miles) includes the relevant lands south of the Moxee Domain, and east and north of the Yakima River (left bank) (fig. 17). The eastern boundary of the domain is the boundary between Yakima and Benton Counties. For this domain, groundwater levels and extent for the basin-fill deposits, Saddle Mountains unit, Wanapum unit, and Grande Ronde unit were analyzed. Other information analyzed included: land ownership, surficial hydrogeology, geologic structure, well logs, location of irrigation districts, groundwater-level hydrographs, recharge, aerial photographs, current zoning, and RLU parcels. The domain contains 1,247 RLU parcels, of which

1,225 are in irrigation districts. There are 28 diversions in the domain with an allowable quantity of 454,861 acre-feet. Mitigation strategies would be oriented to main stem water.

The domain was divided into two sectors (fig. 17), one sector is north of the Roza Irrigation District on the upper slopes of Rattlesnake Hills and the second sector encompasses the irrigation districts and most of the developed or developable relevant lands. Some factors complicate the potential strategies in the upland sector and will be described below.

Figure 17. Location of Rattlesnake Hills Domain and residential land, undeveloped parcels.



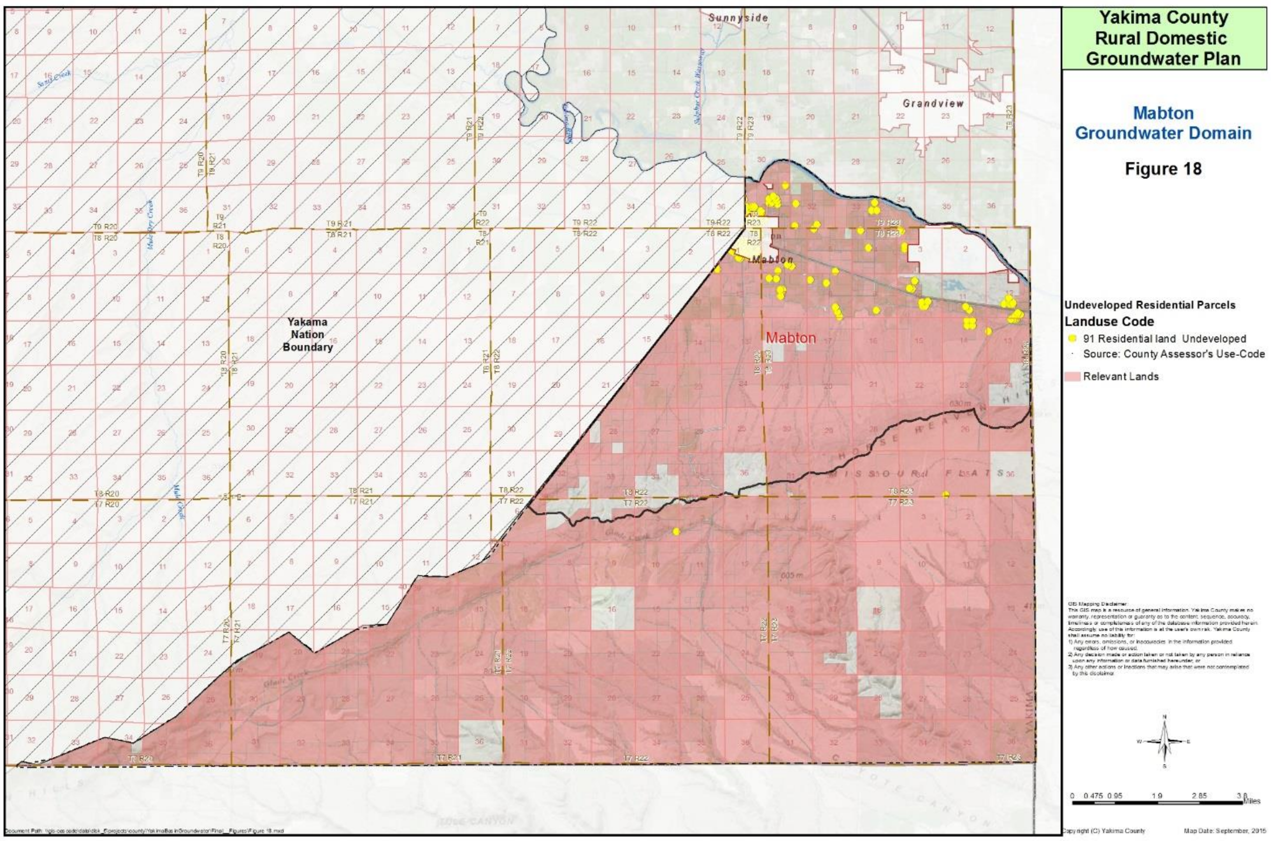
Sector 1 (194 square miles) includes the irrigation districts present on Rattlesnake Hills such as Sunnyside Valley, Roza, and Union Gap. The delivery and use of surface-water in the irrigation districts provide a source of recharge (more than 10 inches per year and in some areas more than 20 inches per year; Vaccaro and Olsen, 2007) to the system. The sector includes the Cities of Zillah, Sunnyside, Granger, and Grandview. Except for the northern and eastern part of this sector, the area is typified by basin-fill deposits generally over 200 feet thick. That is, basin-fill deposits over more than two-thirds of this sector are almost everywhere greater than 200 feet, and over about one-half of the sector they are greater than 400 feet. In the smaller, southeastern part of this sector, the deposits are thinner and future residential wells may need to be finished into the Saddle Mountains unit. Most of the existing domestic wells in the sector are finished in the basin-fill deposits and much of the future pumpage in this sector would occur from these deposits except along the peripheral boundary with sector 2 or where the basin-fill deposits thin towards the east. Future wells near the boundary between the two sectors likely would be needed to be drilled deeper than wells downslope. Groundwater-level hydrographs indicate stable water levels in these deposits. The groundwater levels for the units indicate that future withdrawals from the basin-fill deposits would have minimal, if any, affect, on the deeper Wanapum and Grande Ronde units

Sector 2 (51.8 square miles) only contains 1 RLU, and it is located above the Roza Irrigation District, extends to the crest of Rattlesnake Hills, and is bounded to the east by the Yakima-Benton County line. As stated previously for the Moxee Domain sector 3, no explicit well depths are defined and if they were, there would be no guarantee that a well would penetrate a water-producing zone for a depth because there is little information on wells and water levels over much of this sector. The existing wells along both sides of the boundary between it and sector 1 are generally deeper than wells downslope (downgradient)--suggesting any new wells in this sector may be deeper wells. This sector is in the upper part of the hillslope where groundwater recharge is limited because of the low precipitation quantities (Vaccaro and Olsen, 2008) and there is only a small upstream contributing area to the groundwater flow system. Future development in this sector needs to be aware that it may be prone to declines due to increased pumpage. However, the limited amount county relevant lands (52 square miles) in this sector generally are zoned agriculture or remote/extremely limited, and the impacts for future county-wide development may be minimal.

Mabton

The Mabton Domain (40.9 square miles) includes the area north of Horse Heaven Hills (defined by the ridge line), east of the Yakama Nation boundary, south of the Yakima River, and west of the Yakima-Benton County line (fig. 18). All mitigation strategies would be oriented to the Yakima River. This sector contains 87 RLU parcels (79 in the Roza Irrigation District) and no diversions. For this domain, groundwater levels and extent for the basin-fill deposits, Saddle Mountains unit, and Wanapum unit were analyzed. Other information analyzed included: land ownership, surficial hydrogeology, geologic structure, well logs, location of irrigation districts, aerial photography, groundwater-level hydrographs, recharge, current zoning, and RLU parcels. The domain has no sectors but because it included an ACA identified in WDOE's Scoping Map, the upland area was analyzed in more detail for potential effects of future new residential pumpage.

Figure 18. Location of Moxee Domain and residential land, undeveloped parcels.



The lower, flat-lying part of the domain where the City of Mabton is located, includes the Roza Irrigation District. The southern boundary of this part closely follows the 700 foot water-level contour for the Saddle Mountains unit of Vaccaro and others (2009). All of the 87 RLU parcels are in this part, representing about 0.047 cubic feet per second (34 acre-feet) of long-term future demand. Total consumptive use would be about 0.12 cubic feet per second (8.8 acre-feet), but there is a potential for a large reduction in this quantity because 91 percent of the parcels are in an irrigation district. Recharge over most of this area is more than 10 inches per year (Vaccaro and Olsen, 2007) because of the influence of surface-water irrigation. This recharge will moderate any potential groundwater level declines due to future residential pumpage. The southern boundary of this area is near the slope break between the steeper uplands and the flat-lying lowlands. Well information suggests that this boundary approximates the transition from downward to upward flow. In the upper part of the basin-fill deposits and the Saddle Mountains unit flow tends to be lateral. Groundwater levels also indicate that they tend to the level of the Yakima River. The land surface gradient ranges from about 40 to 115 feet per depending on the distance to the river. These gradients are larger than the hydraulic gradient--showing the relative flatness of the hydraulic gradient. Both the land surface and hydraulic gradient in this area are much smaller compared to those in the uplands. Most wells would intercept groundwater moving to the river, that is, there likely would be minimal effects on the hydraulic gradient upstream of the slope break. Although shallow wells exist throughout this area, it is recommended that wells be drilled to more than 100 feet and finished with a good surface seal to prevent potential contamination from surface sources. It is also recommended that new residential wells generally be less than some 300 feet deep because deeper wells would mainly abstract water from the sub-regional groundwater system emanating from the uplands. Deeper wells would be more prone to groundwater level declines as shown by the long-term trend in levels from a deeper basalt well near the northwest corner of the domain.

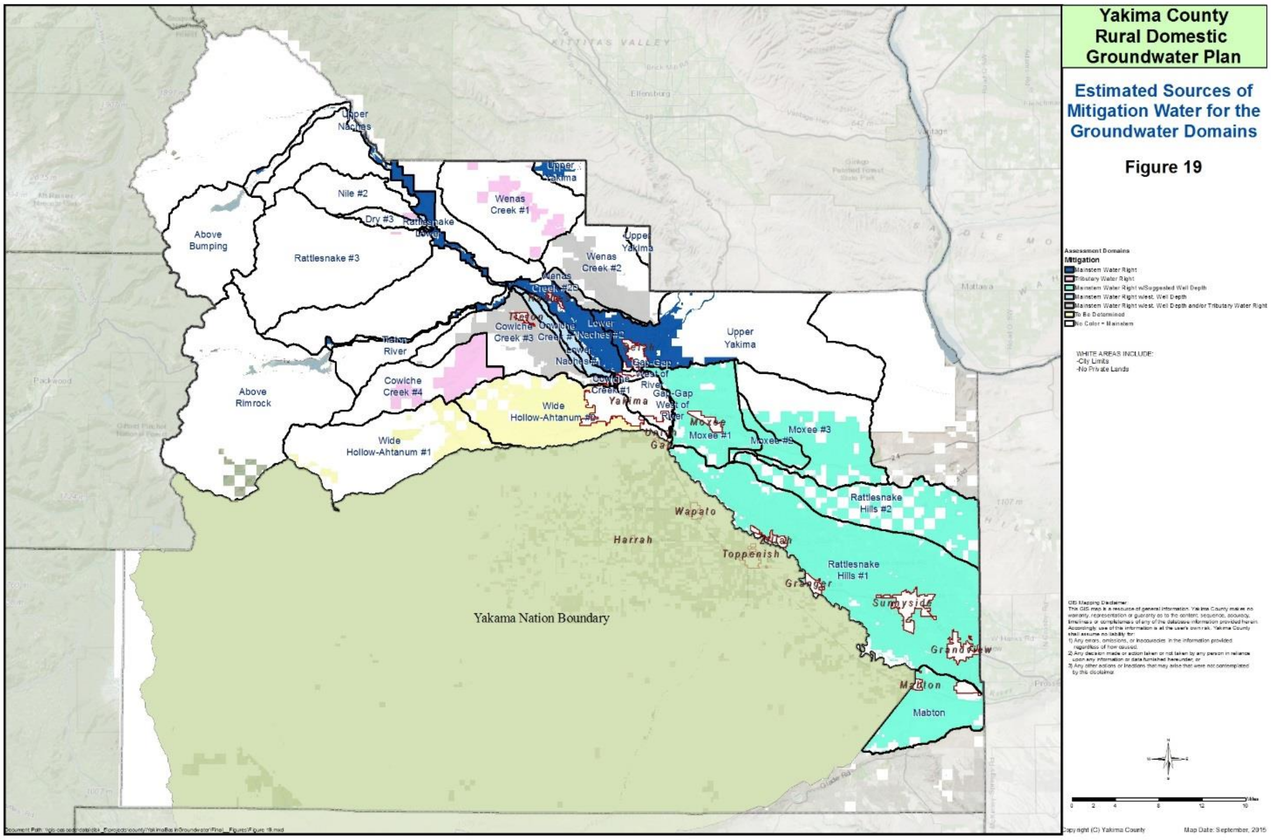
The uplands (covering some 28 square miles) extends to the ridge line for Horse Heaven Hills. This area is relatively dry (on average there is generally less than 8.5 inches per year of precipitation) and groundwater recharge quantities are small (Vaccaro and Olsen, 2007). The combination of low recharge and a small contributing area to the aquifers makes it potentially susceptible to declines as evidenced by declines displayed in a groundwater-levels hydrograph from a deep basalt well. Although zoned agricultural, if development does occur in the future, it needs to be recognized that there is the possibility of localized long-term declines (albeit likely small due to the small amount of pumpage from residential wells). Newer agricultural wells may exasperate potential declines, but any declines likely would not extend far into the lowlands were most development will occur due to the excess recharge there. Also, the depths of agricultural wells generally are deep and would not capture much of the shallow flow system.

Groundwater Mitigation Strategies

The characterization of groundwater domains led to the selection of groundwater mitigation strategies and estimated sources of mitigation water for rural development that avoid impacts to tributaries, which include purchase of main stem rights, purchase of tributary rights where they are available, and identified and suggested well depth standards. Due to the lack of water markets in most tributaries, there was a strong emphasis on the development of well depth standards in the tributary basins that would mostly avoid impacts to flows in the tributaries, and would impact flows/senior rights in the main stem reaches.

For each domain, an estimated source of mitigation water for future rural development is identified below. In other domains where there are indications that the deeper basalt aquifers are declining, it also is possible to limit well depth to avoid impact to those aquifers and the groundwater rights associated with them. Mitigation strategies for individual domains are primarily directed towards mitigation of the effects upon senior water-right holders in the basin. The effects of future water development in part of a domain may be met by mitigation of the main stem water supply, and in another part the effects of such development may necessarily only be by mitigation of a tributary water supply. This analysis is conservative in regards to actual negative impacts to tributary surface waters since the groundwater withdrawn for residential use is imported into the surface of the basin, non-utilized groundwater (74 percent) will discharge to the surface aquifers and increase stream flows. Figure 19 shows the domains (and sectors if applicable) that are colored coded by the estimated mitigation source or method (that is, an estimated well depth for future water supply). The figure clearly shows the differentiation between the potential sources of mitigation water.

Figure 19. Estimated Sources of Mitigation Water



Specific strategies for mitigation of the effect of future rural domestic groundwater withdrawals (sources of water) are shown below by domain. Tables 2 to 5 show the (1) area of County relevant lands, (2) number of RLU parcels in each as of July 2015, and (3) the estimated source of mitigation water for each domain and sector.

Table 2 – Upper Naches and Tieton Domains

	Upper Naches	Nile Creek #1	Nile Creek #2	Nile/Dry	Dry #1	Dry #2	Dry #3
Area of County Jurisdiction Lands (square miles)	11.42	0.3	0.78	0.02	0.09	0.05	0.03
Buildable Lots[1] (not in Municipalities)	299	0	0	2	1	0	0
Mitigation[2]	M	MWD	NA	MWD	MWD	NA	NA

	Rattlesnake #1	Rattlesnake #2	Rattlesnake #3	Lower Rattlesnake	Tieton	Lower Naches #1	Lower Naches #2
Area of County Jurisdiction Lands (square miles)	0.15	0.22	0.24	0.17	1.97	7.93	24.25
Buildable Lots[1] (not in Municipalities)	9	0	0	1	13	108	378
Mitigation[2]	MWD	NA	NA	MWD	M	MWD	M

1. Buildable Lots defined as Residential land, Undeveloped (County Assessor)

2. M - Main stem water rights

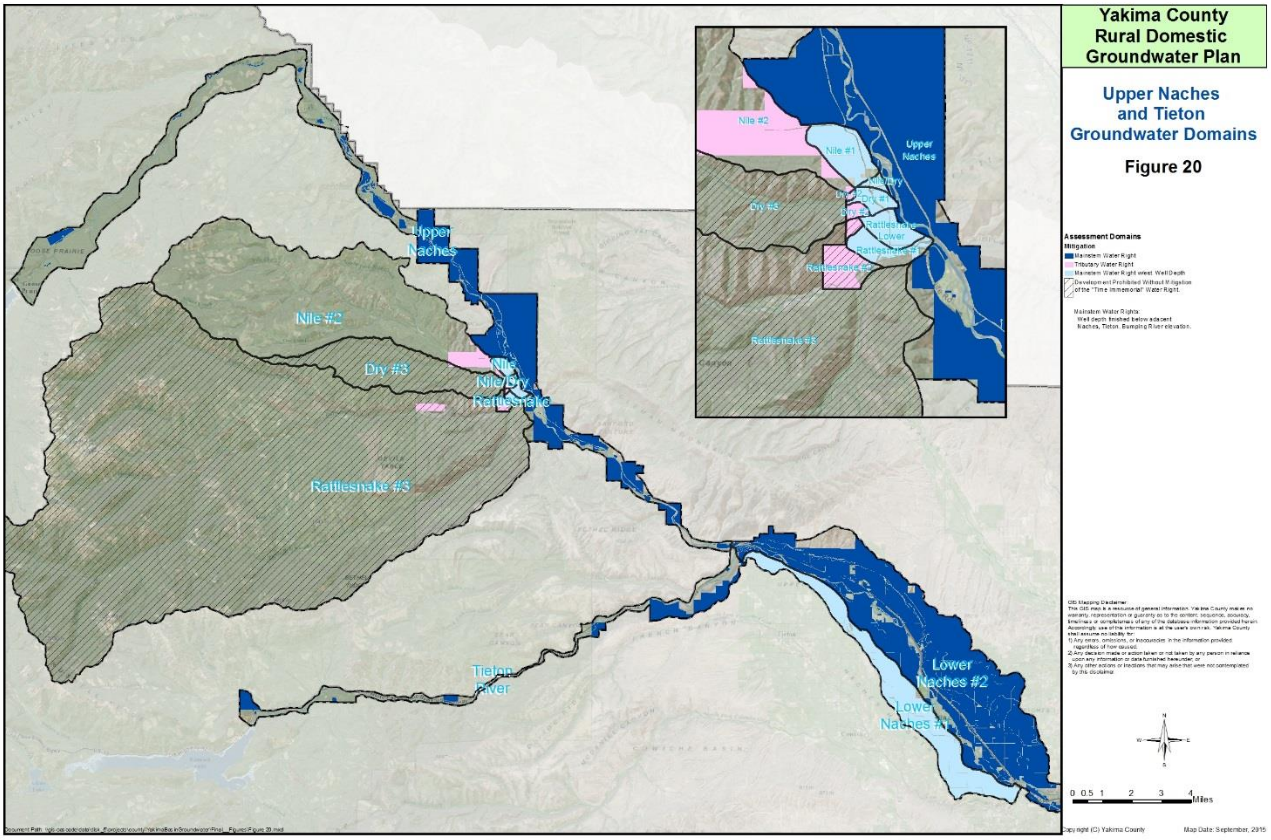
MWD - Main stem water rights with estimated well depths

T - Tributary water rights

MWD/T - Main stem water rights with estimated well depths and/or Tributary water rights

NA- Mitigation not required - no lots entirely in watershed.

Figure 20 – Mitigation Water for Upper Naches and Tieton Domains



For Upper Naches and Tieton Domains (fig. 20) mitigation water will consist of main stem water rights. Well depths would be specified to draw water from the main stem Naches or Tieton in all tributaries. Development of new wells on the portions of the undeveloped lot in Dry Creek Sector 3 and Rattlesnake Sectors 2 and 3 would be prohibited without mitigation of the "time immemorial" water right. Development and approval of a mitigation plan would be the responsibility of the landowner proposing the new groundwater use.

Table 3 – Upper Yakima, Wenas and Cowiche Domains

	Upper Yakima	Wenas #1	Wenas #2	Wenas #2D	Cowiche #1	Cowiche #2	Cowiche #3	Cowiche #4
Area of County Jurisdiction Lands (square miles)	32.6	13.83	27.9	6.19	6.55	0.35	32.85	25.03
Buildable Lots[1] (not in Municipalities)	726	31	236	15	106	17	334	80
Mitigation[2]	M	T	MWD/T	MWD/T	MWD	M	MWD/T	T

1. Buildable Lots defined as Residential land, Undeveloped (County Assessor)

2. M - Main stem water rights

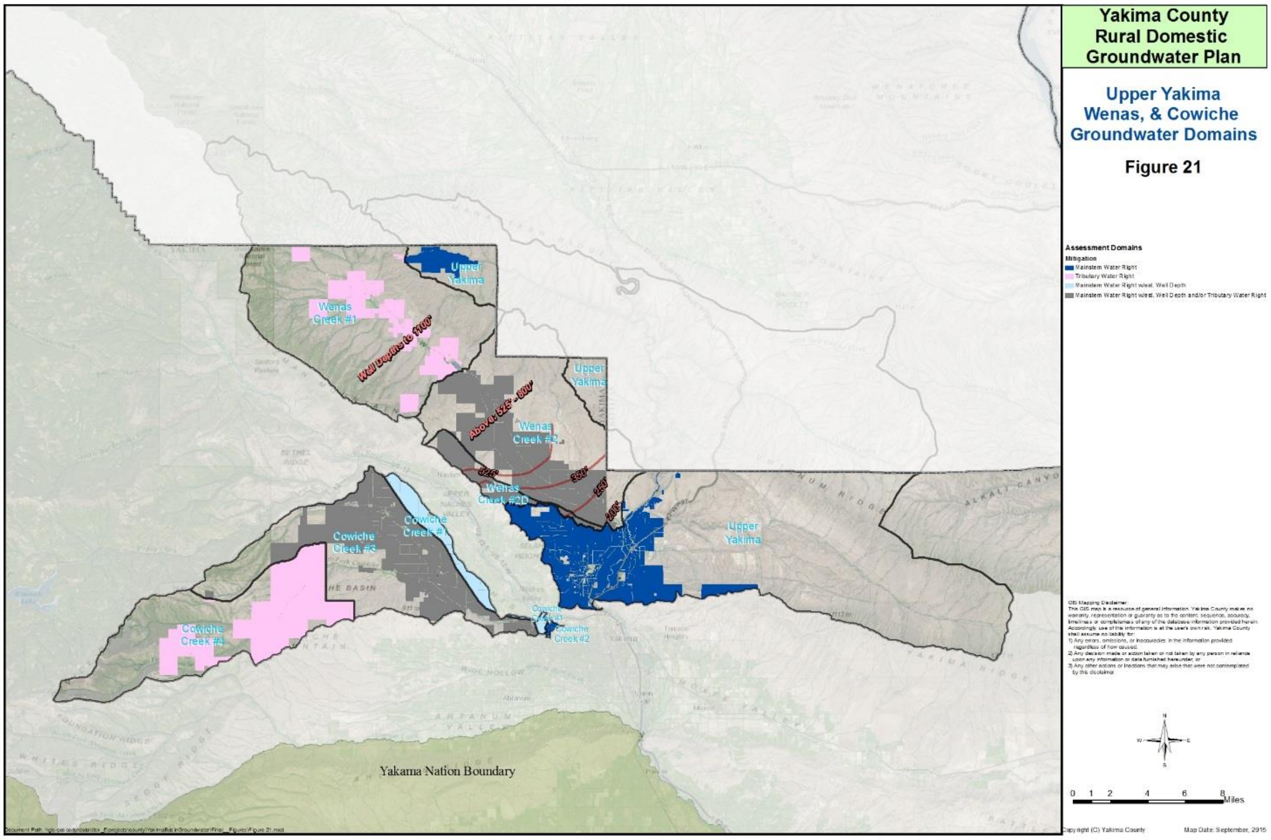
MWD - Main stem water rights with estimated well depths

T - Tributary water rights

MWD/T - Main stem water rights with estimated well depths and/or Tributary water rights

NA- Mitigation not required - no lots entirely in watershed.

Figure 21 – Mitigation Water for <u>Upper Yakima, Wenas and Cowiche Domains</u>



The Upper Yakima (Selah vicinity) (fig.21) area would be mitigated with main stem water rights. The upper Wenas above the dam (Wenas 1) would require acquisition of either:

1. a tributary surface diversion right, or a storage right or
2. a reservoir storage right (this may not be possible legally) or
3. drilling of a deep well (likely over 1100') or a shared deep well system.

Wells in Wenas sectors 2 and 2D require acquisition of tributary rights (reservoir or stream), or main stem rights and specified well depths. The requirements for well depths in most of this area are similar to the depth to which wells must be drilled to provide a reliable source of water, some areas in the lower Wenas would have to bypass one aquifer, resulting in a marginally deeper (50 to 100 feet) well depth.

In Cowiche, Sectors 1 and 2 would be mitigated with main stem water rights. Well depths would be specified with somewhat deeper depths than current wells in Sector 2. Sectors 3 and 4 are in the upper watershed and would likely require both tributary water mitigation and fish habitat mitigation. This is because the undeveloped lots are in the upper watershed, with the available surface water rights well downstream. Development of a well in the upper watershed would therefore reduce flows in a long distance of stream prior to the opportunity to mitigate for senior water rights impacts in the lower Cowiche Creek watershed.

Table 4 – Wide Hollow and Moxee Domains

	Wide Hollow/Ahtanum #1	Wide Hollow/Ahtanum #2	Moxee #1	Moxee #2	Moxee #3
Area of County Jurisdiction Lands (square miles)	20.73	70.72	49.18	11.52	43.52
Buildable Lots[1] (not in Municipalities)	194	1092	1073	46	29
Mitigation[2]	TBD	TBD	MSWD	MSWD	MSWD

1. Buildable Lots defined as Residential land, Undeveloped (County Assessor)

2.

MSWD - Main stem water rights with recommended well depths

TBD – To be determined at a later date.

Wide Hollow and Moxee Domains are shown in Figure 22. In the Wide Hollow/ Ahtanum Domain, further review and cooperation with WDOE and the Yakima Nation is necessary for two reasons –

- The ability to develop a mitigation strategy is limited because the status of water rights in Ahtanum Creek are currently uncertain as this is the last sub basin to be adjudicated (final determination of water rights) in the Yakima River Basin.
- The hydrogeologic conditions in that basin are extraordinarily complex, as is the water resource management regime.

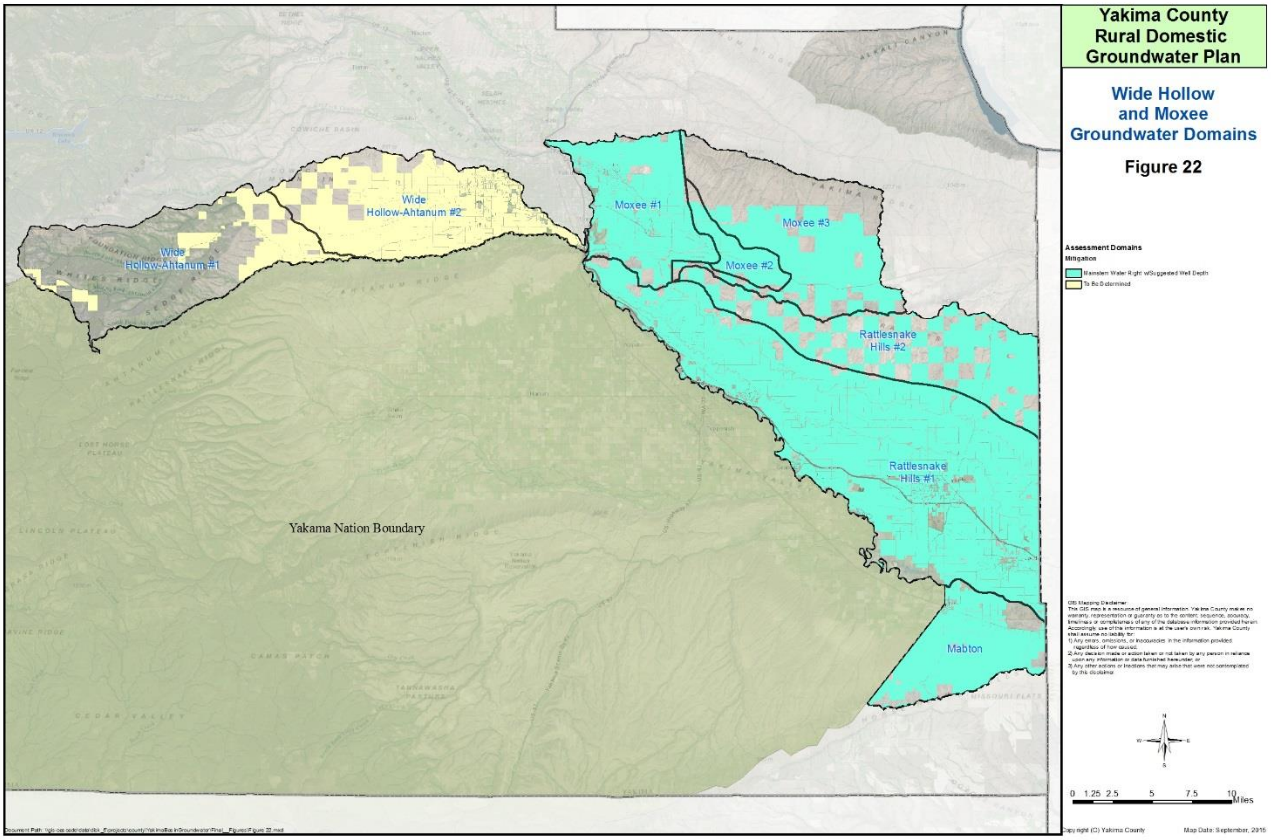
Mitigation may require additional actions, such as using main stem rights to supply an aquifer recharge facility designed to improve flow in Ahtanum Creek, which are unique to that system. In the Moxee watershed, only limited areas would require a specific or suggested well depth.

It is known that there are known areas of water-level declines in the Moxee valley, and it is likely that later Comprehensive Plan review will limit the development of new wells in some of this area.

Table 5 – Mabton and Horse Heaven Hill Domains

	Mabton #1	**Mabton #2**
Area of County Jurisdiction Lands (square miles)	13.08	27.79
Buildable Lots[1] (not in Municipalities)	87	0
Mitigation[2]	M	M

Figure 22 – Mitigation Water for Ahtanum/Wide Hollow, Moxee, Rattlesnake Hills and Mabton Domains.



Mabton and Horse Heaven Hill Domains also rely on main stem water rights. The source of this mitigation water may be different as the major party (Kennewick Irrigation District) that would make a "call" is a junior district, and therefore it may be possible to use post 1905 water for mitigation in this reach. It should also be noted that there also are a few areas of known groundwater declines in these domains that may trigger other actions by WDOE or in Comprehensive Plan review. However, WDOE recently (2015) issued a groundwater irrigation permit in the Mabton domain as the applicant's contractors analysis showed an availability of groundwater.

Taken across all existing lots in all of the domains, it is possible (using well depth requirements) to provide for from main stem sources on 79% of all the existing vacant residential lots in the rural areas of the County, or 98% of existing lots outside of the Ahtanum/Wide Hollow drainage.

In order to be able to meet projected demands, the Yakima County Water Resource System should have a sufficient quantity of mitigation water rights available to ensure that demands can be met for a period of time. Based on a forecasted 5 year demand of 705 new residences not currently serviced by existing municipal services, domestic usage of 350 gallons per day, and 24 percent consumptive use , the total quantity of water rights required by the YCWRS would be 66 acre feet . Based on projected development across the various sectors and domains noted in this section, and the likelihood that groundwater mitigation in the Wide Hollow/ Ahtanum Domain will also require main stem rights, 99% of the necessary supply would be main stem rights.

In the near term, available water rights and supply will be limited to the purchase of existing senior water rights, over the medium and longer term, other sources such as surface or groundwater storage are being actively pursued. Other mitigation strategies, not presented here, could be used for long term acquisitions and could include actions such as improving irrigation efficiencies (which may not produce very much consumptive use for large-scale mitigation but can meet mitigation demands for local small-demand domestic well use), purchase of rights or a variety of contractual agreements within individual tributary drainages (watersheds), placement of water rights into the trust water right program, artificial recharge of groundwater or storage of surface water, and implementation of aquatic habitat restoration or protection actions in lieu of water quantity mitigation. Ongoing water resource planning and implementation programs such as the Yakima Basin Integrated Plan can cooperatively develop, facilitate and implement these types of approaches over the long term.

In order to implement the selected mitigation strategies Yakima County would need to get agreement from the WDOE that this type of water transfer is in the public interest, and work with WDOE on the procedural aspects of conversion of the water rights. Since the conversion of irrigation rights will necessarily change how those rights are stored and operationally managed by the Bureau of Reclamation, those rights will require year to year management, like all other senior rights, and can use existing agreements.

Implementing these selected groundwater mitigation strategies will require the development of a program to ensure that residential wells are constructed to withdraw water according to the hydrogeologic conditions described within each domain by the use of physical data such as adequately located well logs tied to appropriate sectors.

Data incorporated in this analysis is subject to change due to modifications of water sources and infrastructure, increased data resolutions or other technological advances, and development pressures. For example, new State regulations could alter the potential sources in some domains or specific environmental needs, not incorporated in this analysis, may supplant the potential sources. It is also recognized that the groundwater system in the Yakima River basin within the County is complex and that the depths for wells are not exact. Other factors, such as the availability of water for purchase, can limit the choice of strategies.

References Cited

Bureau of Reclamation, 1999, Yakima River Basin Water Enhancement Project, Washington, Final Programmatic Environmental Impact Statement: U.S. Department of Interior, Bureau of Reclamation, Pacific Northwest Region, Upper Columbia Area Office, Yakima, Washington, 197 p.

Bracken, Nathan, 2006, Exempt well issues in the West, prepared by: Legal Counsel, Western States Water Council, 253 p., copy at: *www.ecy.wa.gov/programs/wr/wrac/.../**ExemptWell**IssuesintheWest.pdf*

Ely, D.M., Bachman, M.P., and Vaccaro, J.J., 2011, Numerical simulation of groundwater flow for the Yakima River basin aquifer system, Washington: USGS Scientific Investigations Report 2011-5155, 90 p.

Jones, M.A., Vaccaro, J.J., and Watkins, A.M., 2006, Hydrogeologic framework of sedimentary deposits in six structural basins, Yakima River basin, Washington: U.S. Geological Survey Scientific Investigations Report 2006-5116, 24 p., accessed September 29, 2014 at http://pubs.usgs.gov/sir/2006/5116/

Jones, M.A., and Vaccaro, J.J., 2008, Extent and depth to top of basalt and interbed hydrogeologic units, Yakima River basin aquifer system, Washington: U.S. Geological Survey Scientific Investigations Report 2008-5045, 22 p., accessed September 29, 2014 at http://pubs.usgs.gov/sir/2008/5045/

Keys, M.E., Vaccaro, J.J., Jones, M.A., and Julich, R.J., 2008, Hydrographs showing ground-water level trends for selected wells in the Yakima River basin aquifer system, Washington: U.S. Geological Survey Data Series 343, 1 p.

Kirk, T.K., and Mackie, T.L., 1993, Black Rock-Moxee Valley groundwater study: Washington State Department of Ecology, Open File Technical Report 93-1, 79 p., accessed April 1, 2015, at http://www.ecy.wa.gov/biblio/oftr9301.html

Mastin, M.C. and Vaccaro, J.J., Watershed models for decision support in the Yakima River Basin, Washington: USGS Open-File Report 02-404, 46 p

Vaccaro, J.J., and Sumioka, S.S., 2006, Estimates of groundwater pumpage from the Yakima River Basin aquifer system, Washington, 1960-2000: USGS Scientific Investigations Report 2006-5205, 56 p.

Vaccaro, J.J., and Olsen, T.D., 2007, Estimates of groundwater recharge to the Yakima River Basin aquifer system, Washington, for predevelopment and current land-use and land-cover conditions: USGS Scientific Investigations Report 2007-5007, Version 1.2 April 2009, 30 p.

Vaccaro, J.J., Jones, M.A., Ely, D.M., Keys, M.E., Olsen, T.D., Welch, W.B., and Cox, S.E., 2009, Hydrogeologic framework of the Yakima River Basin aquifer system, Washington: USGS Scientific Investigations Report 2009-5152, 106 p.

Appendix A. Potential Mitigation Strategies

The following strategies are listed as potential alternatives, are not inclusive, and are not prioritized:

- Purchase a pool of both pre-1905 and post-1905 surface-water rights. This portfolio of rights would be for both main stem and tributary basins. Convert to municipal rights and put into trust for managing water for those entitled to establish wells for domestic use under RCW 90.44.050.
- Integrate existing Group A and B systems within the County, which would also address current and potential public health issues.
- Incorporate, where possible, existing exempt well rights into the Yakima County Water Resource System for connection to municipal systems.
- Participate with the City of Yakima in acquisition of Boise Cascade property and appurtenant water rights. Invest in the City's aquifer recharge project to establish water credits for rural areas in dry years.
- Convert water use rights for existing exempt wells in municipal areas to the municipal water system and connect users to system.
- Work with Nob Hill Water District to expand existing delivery systems in its boundaries and convert, where possible, exempt wells to the District's water system.
- Invest in conservation measures in selected irrigation districts to obtain water credits for development.
- Invest in water conservation strategies for existing water users in the County. This would include metering of water, and possibly such aspects as investing in partial or complete lawn removal.
- Define well construction practices in selected areas to mitigate against tributary basin impacts.
- Implement changes in zoning and or building codes in select areas.
- Improve/create habitat that is currently poor or has been eliminated due to human activities.

- Add new habitat because this can have a much larger beneficial effect on fish habitat than mitigating for small reductions in streamflow
- Forbearance- surface-water users accept impact during prorating years in exchange for a defined monetary value
- Lease and fallow land that is irrigated with surface water during prorating years
- For selected reaches of tributary streams, implement deep groundwater pumpage during part of the irrigation season and discharge pumped water to stream.
- Assess acquiring junior groundwater irrigation rights and retire them. This strategy would have long-term, year-in-year-out beneficial effects on streamflow and the sustainability of the groundwater resource.